HABITAT UTILIZATION OF WILD UNGULATES OF KEOLADEO NATIONAL PARK BHARATPUR, RAJASTHAN

DISSERTATION SUBMITTED
IN PARTIAL FULFILMENT FOR THE DEGREE OF

Master of Philosophy

IN

WILDLIFE SCIENCE

BY

MD. NAYERUL HAQUE

CENTRE OF WILDLIFE & ORNITHOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

1988

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CENTRE OF WILDLIFE & ORNITHOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH- 202001

Tel: Office: 3942
Res : 4359

Dr. A.H. Musavi
Chairman

CERTIFICATE

This is to certify that the dissertation "Habitat Utilization of Wild Ungulates of Keoladeo National Park, Bharatpur, Rajasthan" submitted for the award of M.Phil degree in Wildlife Science, of the Aligarh Muslim University, Aligarh, is the original work of Mr. Md. Nayerul Haque. This work has been done by the candidate under my supervision.

October 30, 1988

(A.H. Musavi)
Chairman
Centre of Wildlife & Ornithology
Aligarh Muslim University, Aligarh

Phone : 3282

Bombay Natural History Society
Ecological Research Centre
Bharatpur 321 001

C E R T I F I C A T E

The work on "Habitat utilization of wild ungulates of Keoladeo National Park, Bharatpur Rajasthan" has been done by Mr.Md. Nayerul Haque in Keoladeo National Park as a part of the Bharatpur Ecological Project under my supervision. All the data contained in the dissertation has been collected by Mr.Md.Nayerul Haque and has not yet been submitted for any degree elsewhere.

DR. V. S. VIJAYAN
PROJECT SCIENTIST

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C O N T E N T S

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1. INTRODUCTION

The flora and fauna of the Indian Sub-continent, till a few decades back, was both varied and abundant. But the developments like agricultural expansion, urbanization etc. have directly or indirectly resulted in deforestation which has very adversely affected wildlife. Many species of flora and fauna have become extinct during the last hundred years or so and many more are threatened. The populations of most are fast depleting. Had the government not set up several national parks, many more species of mammals would have become extinct. Though there are many causes of this state of affairs, the major cause of wildlife depletion is habitat destruction. It seems necessary, therefore, to know the wildlife habitat requirements for the effective conservation and management. This study is a step in that direction.

Habitat may be defined as an area of space which possesses environmental components essential for the continued existence of a species (Ables 1974). According to Teaque(1987) a habitat element important for most kinds of the wild game is interspersion. It is the proper positioning, confirguration and size of the kinds of vegetation which is needed to sustain the species. Population size and density of wild game usually depends on the interspersion of habitat types and their relation to the daily and seasonal movements of the concerned animal species.

Quite a few studies have been done particularly in the western contries on the habitat utilization of ungulates in various parts of the world. Martinka (1968) worked on the habitat relationships of white-tailed deer (Odocoileus virginianus) and mule deer (Odocoileus hemionus) in Montana. While Seal et al. (1978) worked on white-tailed deer (Odocoileus virginianus) to know the habitat differences through metabolic indicator. Singer (1979) studied the relationship between the habitat partitioning and wildlife, on moose (Alces alces), elk (Cervus canadensis) and white-tailed deer (Odocoileus virginianus) in Glacier National Park. Cairns and Telfer (1980) worked on four sympatric ungulate species viz. moose (Alces alces), wapti (Cervus canadensis), white-tailed deer (Odocoileus virginianus) and bison (Bison bison). Armbruster and Porath (1980) studied the habitat preference of white-tailed deer (Odocoileus virginianus). Collins and Urness (1981) worked on the habitat preference of mule deer (Odocoileus hemionus) by pellet group distribution. Collins and Urness (1983) worked on habitat selection of mule deer (Odocoileus hemionus hemionus) and elk (Cervus elaphus nelsoni) Irwin and James (1983) studied the elk habitat use relative to forest succession. Fedyk et al (1984) studied winter penetration by mammals of different habitats in the Biebrza Valley. Chapman et al (1985) worked on the distribution and habitat selection by Muntjac (Muntiacus reevesi). Maublanc, M.L. (1986) studied the use of space by roe deer (Carpreolus carpriolus)

Only stray information is available on the habitat preference of Indian ungulate species through the work of Martin (1977) on the Barasingha (Cervus duvauceli branderi), Green (1985) worked on the Musk deer (Moschus chrysogaster). Rice (1984) studied the ecology of Nilgai Tahr (Hemitragus hylocrius) Berwick (1974) worked on all the ruminants of Gir forest. Prasad and Rao (1984) studied the Blackbuck (Antilope cervicapra). Balakrishnan and Easa (1986) worked on the habitat preference of the larger mammals in the Parambikulum wildlife Sanctuary.

Few Indian ungulates were introduced in Texas and at present they are thriving there. Ables (1974) studied Chital (Axis axis), Mungall (1978) worked on Blackbuck (Antilope cervicapra) while Sheffield et al (1983) studied Nilgai (Boselaphus tragocamelus). The relationship between habitat structure and its utilization by different herbivores has been studied in Chitwan National Park (Mishra 1982) and in Africa (Sinclair and Griffth 1979) but very few such studies on ungulates have been done in India.

The Keoladeo National Park contains seven species of ungulates, namely Chital (Axis axis), Sambar (Cervus unicolor), Blackbuck (Antilope cervicapra), Nilgai (Boselaphus tragocamelus), Feral cattle (Bos indicus), Wildboar (Sus scrofa) Hog deer (Axis porcinus) are very few in number at Keoladeo National Park and

are at the verge of extinction. Out of these seven species, three viz. the Blackbuck, Nilgai and Chital are not found outside the Indian sub-continent and the Sambar is not found outside Asia.

A Project was taken up by the Bombay Natural History Society to evaluate the habitat utilization by ungulates as a *part of the long term studies on the ecosystem of this park.*

Ali, S. and Vijayan (1986) found that the marshes are gradually shrinking and drying up and woodland is expanding. This development apparantely seems to favour wild ungulates since more terrestrial area is becoming available to them. But another parallel development is the fast increasing feral cattle population since 1985. If this trend continues, the wild ungulates are likely to come under heavy pressure due to competition with feral cattle.

2. STUDY AREA

2.1 History

The present area of Keoladeo National Park was a natural depression which by impounding and controlling water level was developed into a waterfowl refuge by the Maharajas of Bharatpur, some 250 years ago (Ali, S. and Vijayan 1985). The main objective of the rulers was to develop it for game hunting, especially waterfowl. Another objective of the ruler was to provide an alternative grazing ground to the domestic cows whose presence on their crop fields was resented by the farmers. There was also some religious sentiment involved in the concern of the Maharaja for providing a grazing ground for the cows.

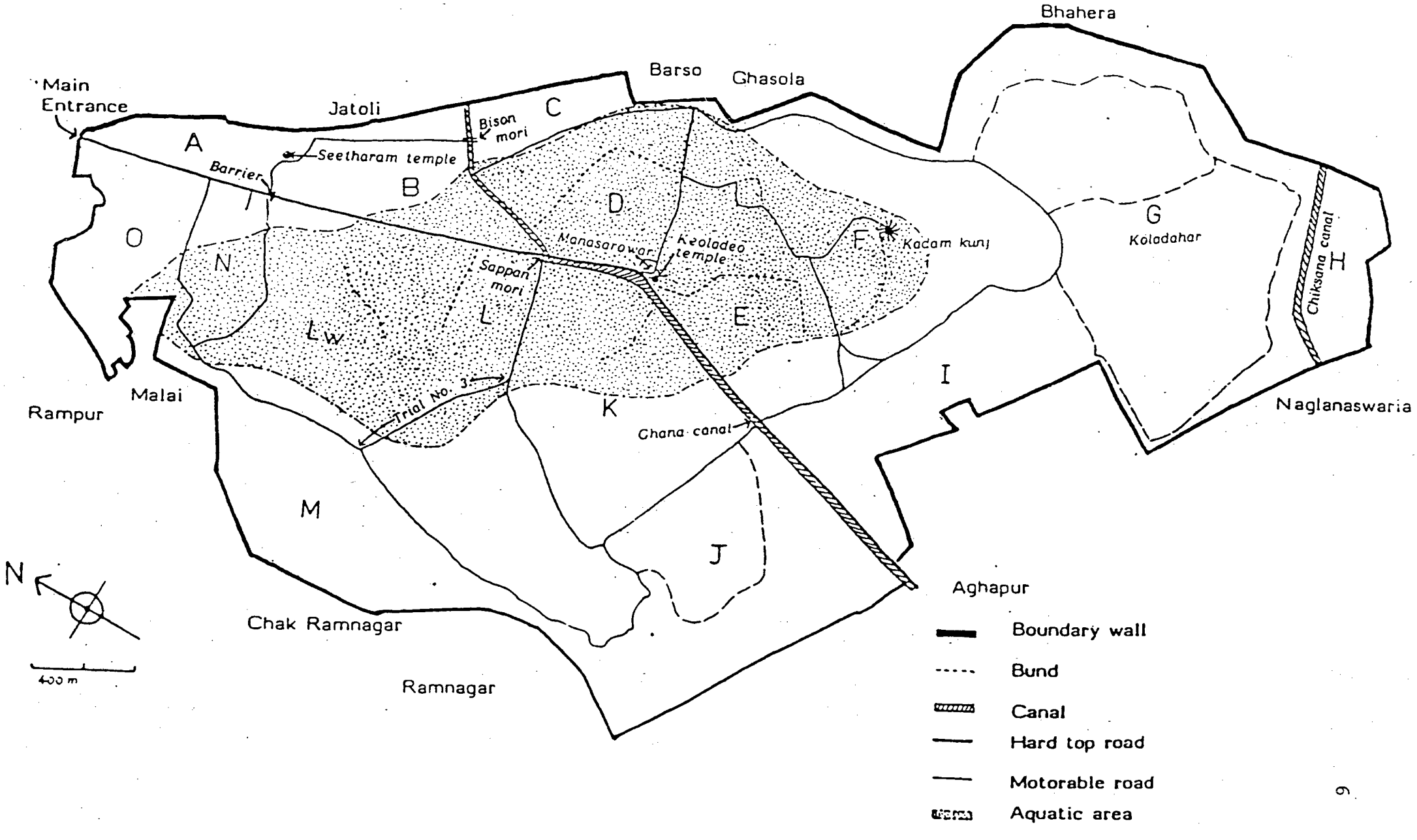
2.2 Location

Keoladeo National Park, situated between 27°7.6' to 27°12.12.2' N and 77°29.5' to 77°33.9'E, is 2 km south-east of Bharatpur city. It is 38 km south-west of Mathura and 50 km west of Agra. The park is located about 180 km south of Delhi.

2.3 Topography

The total area of the park is about 29 sq km. It is more or less flat with a gentle slope towards the centre forming a depression, the total area of which is about 8.5 sq km. This is the main submersible area of the park. The average elevation of

Fig 1: Map of the Park with villages around



the area is about 174 m. above sea level.

2.4 Boundary

A masonry wall around the border separates the park from the surrounding agricultural fields. There are about 14 villages around the park (Fig 1).

2.5 Soil

Thick alluvian dominates the area. Patches of saline soil are common in the terrestrial areas.

2.6 Climate

The climate is sub-tropical with the south-west monsoon as the dominant factor. There are three major climatic seasons.

2.6.1 Monsoon

The monsoon during the study year continues from July to October. The mean minimum temperature during the 1986 monsoon was 22.59° C and mean maximum was 34.06°C. The mean humidity varied from 50.36% in September to 66.71% in August. The maximum rainfall during the period was 98.3mm in September and the minimum precipitation was 36.8mm in October (Fig 2).

2.6.2 Winter

The winter season continued from November 1986 to February 1987. The mean minimum temperature recorded during the study period was 5.36°C and mean maximum temperature 23.02°C.

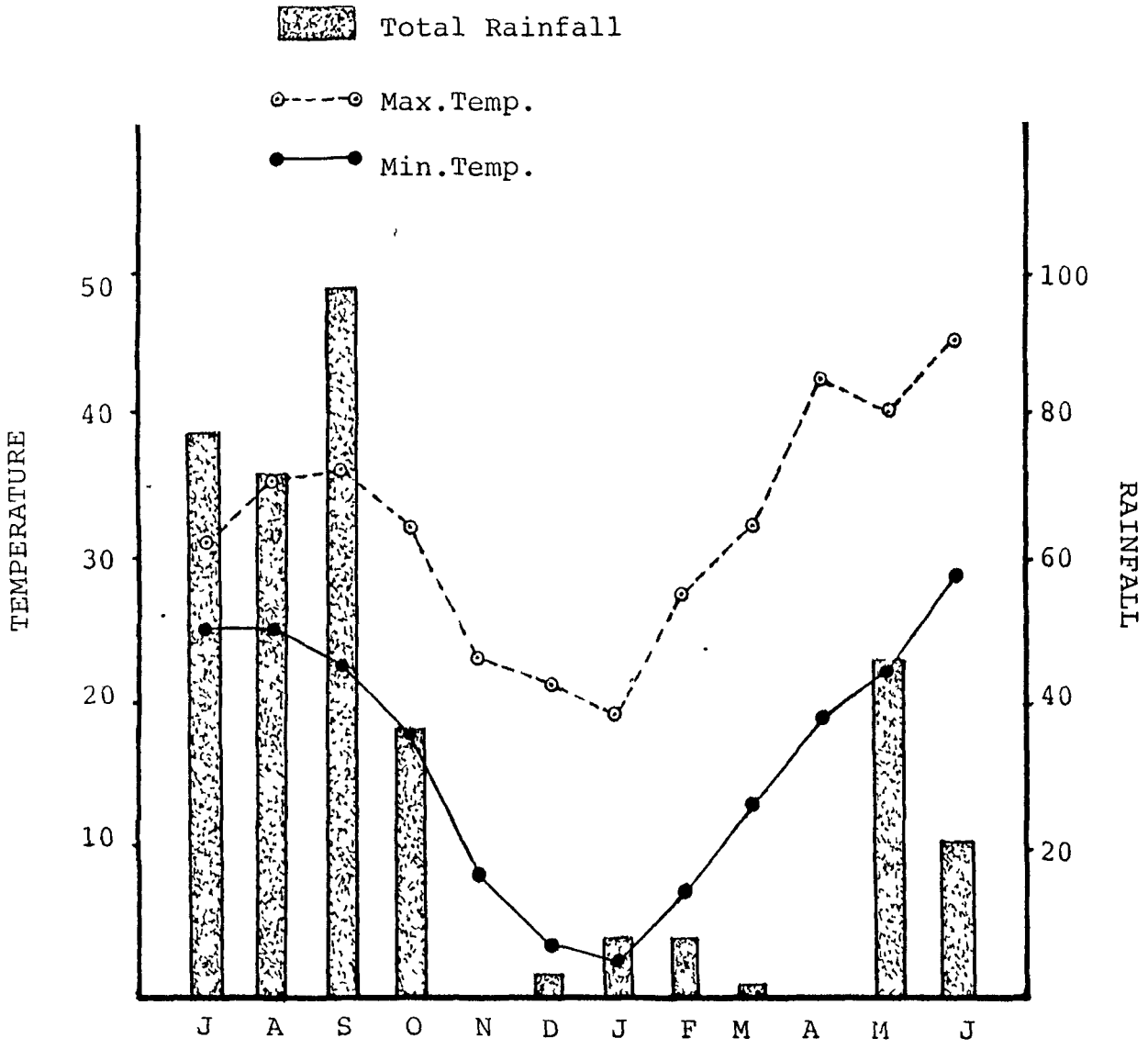


Fig 2 : Temperature and Rainfall of Keoladeo National Park during July 1986 to June 1987

The mean humidity varied from 64% in January to 74.28% in November. The maximum rainfall during the study year was 8.4 mm in January and minimum 3.0 mm in December. There was no rainfall during November 1986 and January 1987 (Fig 2).

2.6.3 Summer

The hot and dry season extended from March to June. The mean temperature varied from 20.94°C (minimum) to 40.17°C (maximum). The mean humidity varied from 54.69% in April to 61.67% in June. The maximum rainfall was 46.2 mm in May and minimum 1.0 mm in March. No rainfall was recorded during the month of April (Fig 2).

2.7 Hydrology

Apart from rain water which is very small in quantity, the major quantum of water is received from Ajan bund, a temporary reservoir outside the Park. The Ajan bund receives water from the two rivers Banganga and Gambir. Water from Ajan bund is released into the park during monsoon.

2.8 Vegetation

The vegetation of Keoladeo National Park does not fit into any of the types mentioned by Champion and Seth (1968). However, the type which comes closest to Bharatpur vegetation is the Babul forest described by Champion and Seth under

VIEW OF WOODLAND

VIEW OF GRASSLAND

Northern dry mixed decidous forest. According to the abundance and structure of the Community the vegetation of Keoladeo National Park can be called as Acacia-Salvadora community. The four major habitats are woodland, grassland, savannah and aquatic (Fig 3).

The study area comprises of 18% woodland, 31% grassland, 20% savannah and 31% aquatic. The main vegetation types found in the study area are represented as such.

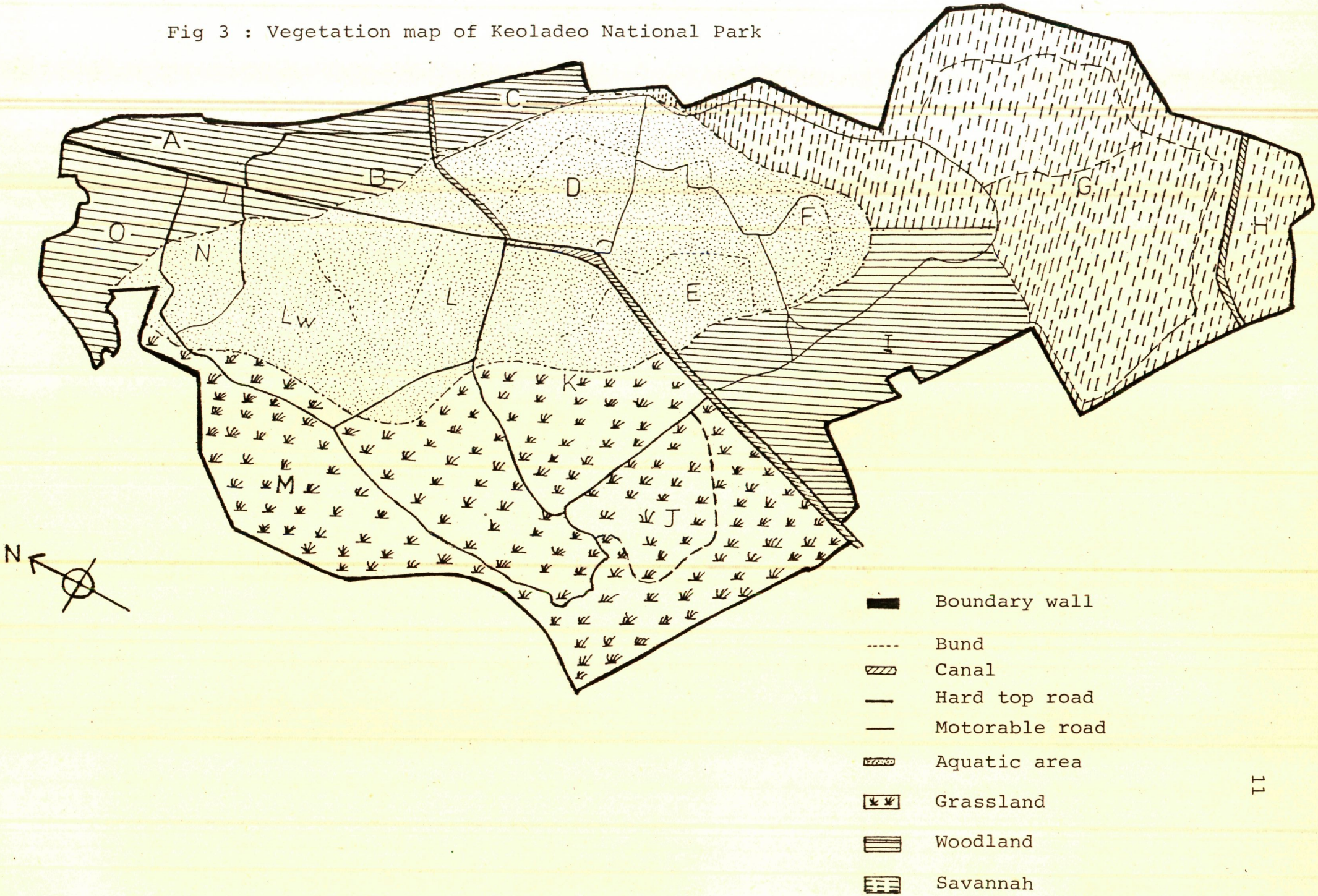
2.8.1 Woodland

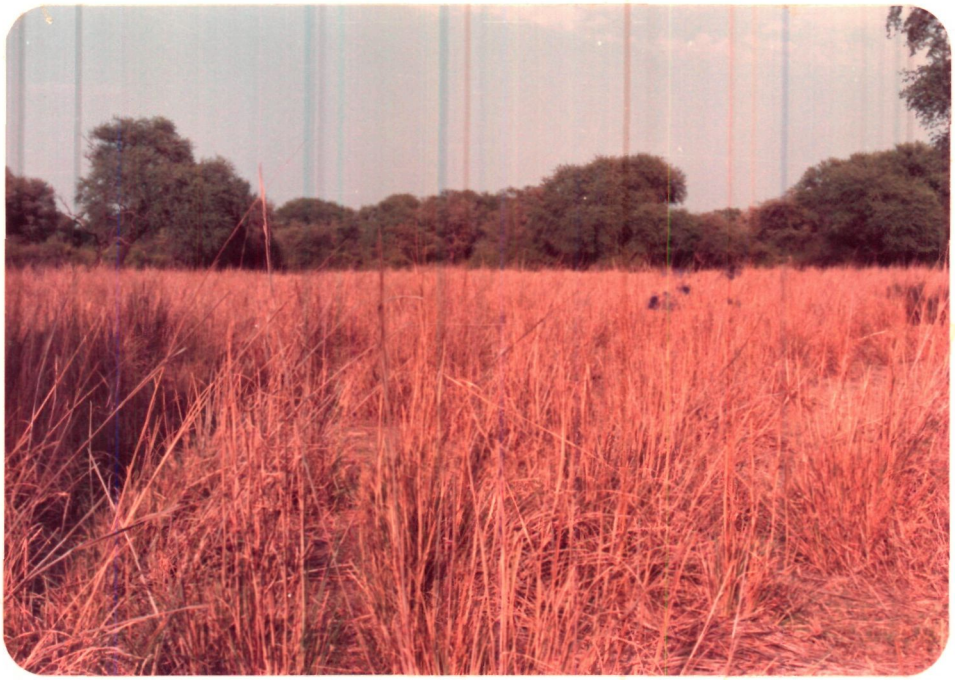
The dominent plant in the woodland is Acacia nilotica which form the upper storey (cover). The other species present in the upper storey are Acacia leucophloea, Zizyphus jujuba, Prosopis spicigera, Crataeva religiosa, Szyzygium cumini, Diosphyros cordifolia. There are two big patches of Mitragyna parvifolia; one in the north and other in the south of the park. The under storey consists mainly of shorter tree and shrubs such as Salvadora perscia, Salvadora oleoides, Prosopis juliflora, Capparis sepiaria Balanites aegyptica, Kirgenelia reticulata, Capparis decidua and Lantana camera. The ground cover is characterized by small herbs such as Calotropis procera, Cassia tora, Convolvulus sps. Commelina forskalli, Corchorus aestuans, Euphorbia hirta and etc..

2.8.2 Grassland

Approximately 31% of the study area is grassland.

Fig 3 : Vegetation map of Keoladeo National Park





VIEW OF SAVANNAH

PATCHES OF SALINE SOIL,
COMMON IN TERRESTRIAL AREA

The height of the grasses vary from 5 cm to 70 cm. This habitat has the maximum diversity of graminae family dominated by Cynodon dactylon, Dicanthium annulatum, Erograstis tanella, Sporobolus spp. Iseilema laxum, Echinochloea colonum. A detailed floral list is given in Appendix I.

2.8.3 Savannah

The savannah habitat is formed by the dense and tall grasses of Veteveria zizanioides associated mainly with Desmostachya bipinnata. The height of Veteveria zizanioides reaches over 2.5 m. Acacia sp. and Zizyphus sp. are scattered in some of the places. The savannah habitat is represented mainly in Koladhar area.

2.8.4 Aquatic vegetation

The aquatic vegetation is emergent, rooted floating, submerged, free floating (Ali, S and Vijayan 1983). The major emergent plants important to herbivores are Paspalum distichum, Cyperus alopecuriodes, Cyperus rotunudus, Scirpus tuberosus, Scirpus articulatus, Eleocharis plantoginea and Ipomoea aquatica Rooted floating includes Nymphoides cristatum and Nymphoides indica. The major submerged plants are Hydrilla verticillata, Utricularia inflexa, Potamogeton crispus, Ceratophyllum demersum and Vallisneria spirolis, Lemna paucicostata, Azolla pinnata and Wolffia arrhiza are the main free floating types. Apart from these, numerous raised mounds are present in the aquatic area

and Acacia nilotica is planted to attract colonial nesting birds.

The poor rainfall and inadequate water supply(1986-87) from the Bund led to a drought condition inside the Park and hence, most of the aquatic area during summer became dry and appeared as an open grassland. In addition to that, a part of the area was bulldozed by the forest department to remove the excessive growth of grass and this created an open patch.

2.9 Fauna

The vertebrate fauna of Keoladeo National Park is quite rich. According to Vijayan (1987) 40 species of fish, 5 species of amphibia, 28 species of reptiles and over 317 species of birds have been described. Twenty nine mammalian species have been recorded (Appendix II) and the six species, on which the present study was conducted, are described in the next chapter and its estimated population is given in Appendix III.

3. STUDY SPECIES

3.1 Chital (Axis axis)

Chital belongs to the genus Axis and is the third largest deer inhabiting the plains of India. The average weight of an adult male is 70 kg while the females are about 20 kg lighter. The average height of a male is 90 cm at shoulder level and that of a female is 75cm. Its coat is rufous brown and covered with white spots. There is a dark dorsal stripe, running down from the nape to the tip of the tail. The underparts, inside of the legs, undertail, and inner side of the ear are white. The antlers are brownish with paler streaks and ivory coloured tips.

The North Eastern part of Gujarat State forms the western limit to its distribution, from where it extends eastwards through most northern provinces of India except the Punjab (Russell 1900). Assam forms its eastern limit. They also occupy forested areas of Peninsular India and Ceylon.

3.1.1 Habits with special reference to habitat selection

The Chitals are gregarious with little nocturnal activity. They are seen in herds of usually ten to thirty which may contain two to three stags. Assemblages numbering upto several hundred have been occasionally seen. It is worth mentioning that the species is distributed in disjointed patches along its range because of large scale habitat destruction and deforestation. It is mostly confined to the national

parks and sancturies where poaching is banned and the habitat is comparitively in a better shape. Some spill over populations are found around the national parks and sancturies. Berwick (1972) working in Gir found that chital prefers flat, primarily mixed teak forested areas. In the moist and evergreen tropical forest of Kanha, the chital mostly utilizes open meadows grazing on short grasses and resting in the forest (Schaller 1967). In Sri Lanka, it uses grasslands and the scrub grassland interface in the semi-dry decidous forest of Wilpattu National Park (Eisemberg and Lockhort 1972). Mishra (1982) working at Chitwan National Park, Nepal found that chital uses both the forest and grassland habitat. From the survey reports of wildlife sancturies of India by Spillet (1968) it is obvious that axis deer are found in a wide variety of ecological types ranging from dry scrub to moist decidous forest. According to Graf and Nichols (1966), the preferred habitat of Axis deer in Hawaii vary from semi-desert shrub areas to rain forests. Ables (1974) mentioned that the chital in Texas (where it was introduced in 1932) prefer similar habitat as described by workers on the basis of their studies in India and Hawaii.

3.2 Sambar (Cervus unicolar)

The Sambar is the largest and most widely distributed deer in India. It belongs to genus Cervus. Adult stags measure 122 to 150 cm at the shoulder and weigh from 225 to 320 Kg. Females are smaller and weigh about 164 Kg. The winter coat of

the sambar is grey-brown to dark brown. Adult stags are slightly darker in colour than hinds. The summer coat is brown to chestnut brown. The rump, the underside of the tail and the inner side ofthe legs are light to rusty brown. Antlers are stout, rugged and normally three tined.

The Sambar is distributed throughout the oriental region wherever there is undulating ground of hilly country with forests. It is found from Sri Lanka in the South and throughout the Peninsula to the fringe of the Himalayas in the north.

3.2.1 Habits with special reference to habitat selection

Its habits are nocturnal. Being very alert and shy of man it is difficult to locate, much less to observe for prolonged periods (Schaller 1967, Prater 1965, Blandford 1888). But the case at Keoladeo National Park is entirely different where the sambar are frequently seen grazing in aquatic area especially in the winter and rainy season. Their sense of sight is moderate. They have a keen sense of smell and hearing. Both stags and hinds are often found singly, but small herds from four or five to a dozen in number are commonly met. The males fight for territory (Prater 1965). The sambar are forest loving animals (Prater 1965, Brander 1923, Blandford 1888).

Schaller (1967) working at Kanha reported that sambar is predominantly a forest dwelling animal, coming out into the

meadows infrequently. Similar observation was made by Berwick (1974) working at Gir forest. According to him sambar prefers the denser forest characterised by hilly tracts and are rare in the open, hilly savannah. According to Mishra (1982) who studied the animal in Chitwan National Park, Nepal, Sambar prefers riverine forest areas.

3.3 Blackbuck (Antelope cervicapra)

The Blackbuck till about five decades back, was the commonest and most conspicious antelope in India. (Brander 1923). The Blackbuck is the sole representative of the genus antelope of the subfamily Antelopinae. Males are 74 to 84cm at shoulder and weigh about 35 kg. Females are slightly smaller and weigh about 32 Kg. Adult bucks are blackish brown above turning to almost black in very old animals and white below. Colour of does and sub adult bucks is yellowish-fawn above and white below. The horns are ringed and spiral three to six time.

Blackbuck is distributed from Pakistan along the foot of the Himalayas to Bangladesh and throughout Peninsular India. It is not found in Assam, West Bengal, Kerala and Sri Lanka.

3.3.1 Habits with special reference to habitat selections

Blackbuck are generally diurnal and found in herds of 10 to 20. Their sense of hearing is moderate, and they have a fair sense of smell, and keen eye sight. In the contrast to the harem formation reported by several workers in different

areas, no harem formation has so far been observed in Keoladeo National Park, the reason are not clearly understood. However, the female group make a large, daily circuit and territorial males join the females as they pass through their territories. Blackbuck has the habit of occasionally springing into the air. It comes to the same spot to deposit dropping. They never enter forest nor high grass and are rarely seen among bushes (Blandford 1888). According to Prater (1965) and Brander (1923), Blackbuck enter open forests which contain wide expanses of grass. Schaller (1967) working at Kanha reported that Blackbuck is adapted to life on the plains, while Pandey et al.(1986) reported from Kanha that Blackbuck are adapted to the grassland habitat. Prasad and Rao (1984), studied Blackbuck in Andhra Pradesh and found that Blackbuck prefer the grassland. Nair (1977) and Daniel (1967) also reported from Point Calimere Sanctuary that Blackbuck prefer grassland habitat. According to Robert (1977) Blackbuck avoid forest areas but survive in semidesert region as long as there is sufficient scattered vegetation.

3.4 Nilgai (Boselaphus tragocamelus)

The Nilgai is a member of the Tribe Boselaphini (Simpson 1945). A male stands 130 to 142cm at shoulder and weighs about 200 kg. Females are smaller weighing 109 to 132 kg. Adult bulls are iron grey and blue grey. Sub adult males and all females are light brown in colour. Both sexes have dark and white markings on their heads, ears, underprarts, fetlocks and tail. Both sexes have a short bristly mane.

The distribution of the Nilgai is from the Himalayan foothills, southward through central India to Karnataka. It is not found in Eastern Bengal, Assam, Malabar coast or Sri Lanka (Brander 1923, Sankhala 1964, Prater 1965).

3.4.1 Habits with special reference to its habitat selection

Males and females remain segregated except during the breeding season, when breeding herds are formed. Four to ten are usually seen together, sometimes as many as thirty or even more. Adult solitary bulls are territorial. Senses of smell and sight are good while hearing is moderately developed in Nilgai. It has a habit of defecating in the same location like other antelopes (Schaller 1967, Brander 1923, Prater 1965). Schaller (1967) suggested that they might be terretorial markers, but Ables (1983) feels that defacation has social importance though its function is unknown. Little information is available on the habitat preference of Nilgai through the work of Prater (1965) and Brander (1923). Both of them have described that Nilgai likes more or less open grassy hill forests sparsely covered with grass. Berwick (1974), working on the ulgulates of Gir forest, Gujarat, reported that Nilgai are most commonly seen in hilly areas vegetated with open teak or savannah.

3.5 Wild boar (Sus scrofa)

The wild boar belongs to the family Suidae. Males are considerably larger than females and stand 84 to 91.5cm at the shoulder. According to Prater (1965) the weight of the male

may exced 230 kg which is almost equal to that of the European Boar (Robert 1977). An adult is a large bulky animal with head appearing as directly joined to the trunk, a barrel shaped body with disproportionately thinner legs. The head has a long muzzle terminating into a disk like structure especially adapted for foraging. The colour of the animal is black mixed with grey, rusty brown and white. The young are brown and have longitudinal stripes. The tushes curve outwords and project from the mouth. These are well developed in the males.

The Indian wild boar is widely distributed in most parts of the Indian Sub-continent, including the lower reaches of the Himalayas, Burma and Sri Lanka.

3.5.1 Habits with special reference to habitat selection

Wildboar is normally a social animal resting and feeding in small groups. Adult males are usually solitary. They are largely nocturnal feeders. The sense of smell is acute, the eyesight and hearing moderate. As far as the author of this report is aware, no detailed study has been done on the habitat preference of Indian Wildboar. Only stray bits of information are available through the work of Prater (1965), Brander (1923) and Robert (1977). Prater (1965) has described that wildboar lives in forest. Brander (1923) found that it exists both inside the forest and in the plains, while Robert (1977) has reported that wild boar need thick cover for shelter, particularly during the day time.

3.6 Feral cattle (Bos indicus)

Jerdon (1874) has divided the sub family Bovinae into three groups one of which Taurine has been subdevided by Blyth into (a) Zebus (b) Taurus and (c) Gavaeus. The common humped cattle of India, seem closest to the feral cattle, belong to the division Zebus.

Jerdon states in "Mammals of India" that in many parts of the country small herds of these animal have run wild. Cows of this type, disowned by their former owners, several generations back, have also found their way into Keoladeo National Park. Being free from domestication their behaviour and appearance has changed to some extent. These are healthier and are comparitively shy of human beings. In all other respects they are like domestic cattle.

A BURNT OUT PORTION OF SAVANNAH IN THE PARK

FRESH SPROUTS OF GRASSES AFTER THE FIRE

4. METHODOLOGY

The study was done from July 1986 to June 1987 and a total of 750 hours were spent in the field. Visual observations were made by traversing a set transect that was carefully laid through all the different habitats (Fig 4). Animals were counted with the aid of a pair 8 x 30 field glasses. The transects were traversed in different hours of the day twice in a month during the first five months of the study period i.e. from July to November 1986. Later, from December 1986 to June 1987 transects were traversed four times in a month.

The visibility or either side of the transect was measured following the method of Hirst (1969). Visibility was measured at every 100 m along the transect, but if any variation in visibility was felt in between the 100 m apart points, it was again measured. All these points were plotted in a map. The visibility varies from 5 to 500 m depending upon the habitat features. A certain part of each habitat was covered by walking on the transects. The area scanned while moving along the transect and its ratio to the total area of the habitat type are given in Table 1. The visibility range increased slightly after the grasses were burnt by an accidental fire in 1986 and, a wider area could be scanned which is shown in Table 2. Density of each species in every habitat was computed on a monthly basis.

Table 1

Area covered in different habitats to sample the animal population densities(before fire)

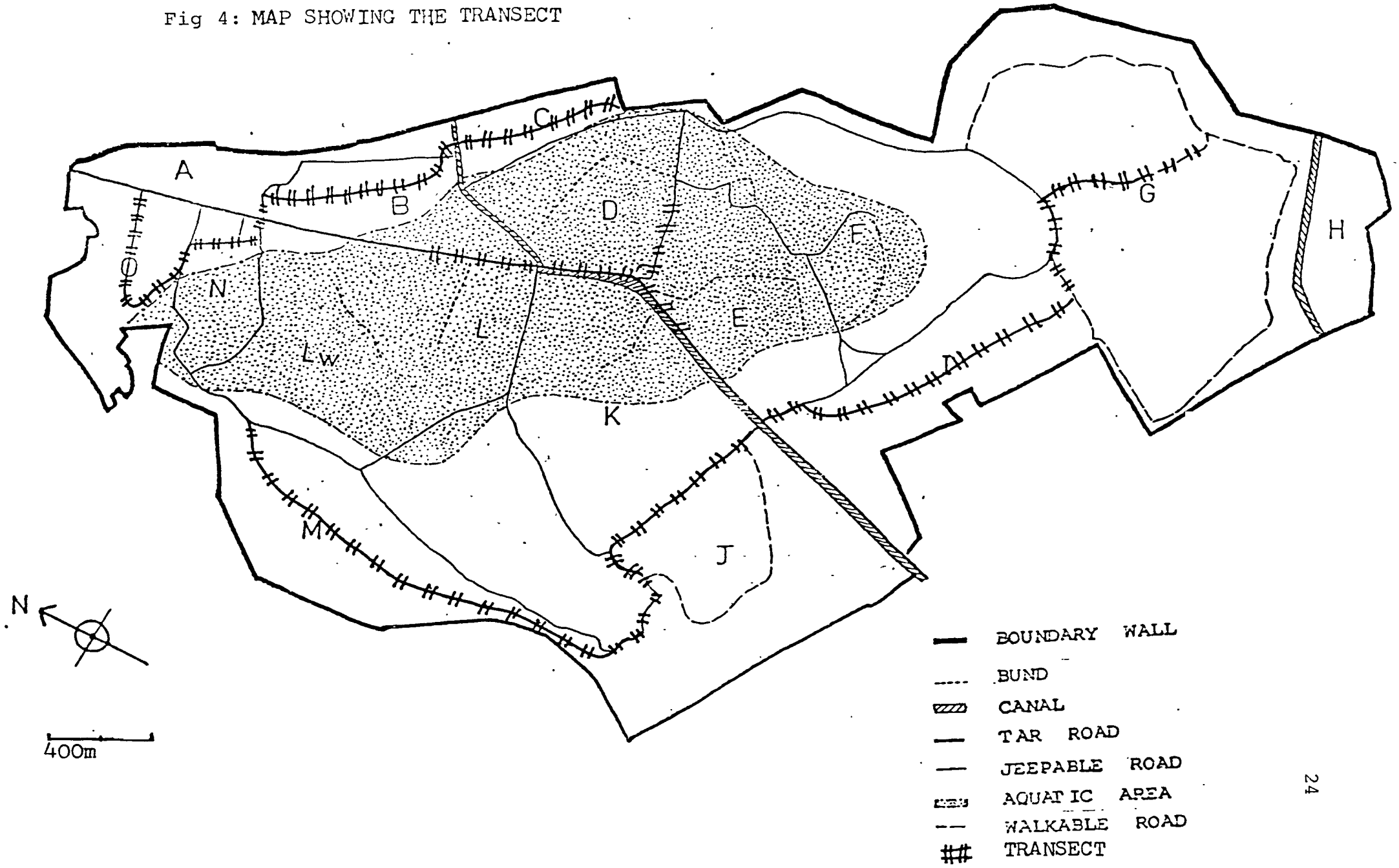
	Total area is Sq.Km.	Area covered in Sq.Km.	Percentage covered
Woodland	5.3	0.6001	12%
Grassland	9.8	1.6185	17%
Savannah	5.8	0.3677	7%
Aquatic	8.5	4.75	55%

Table 2

Area covered in different habitats to sample the animal population densities (after fire)

	Total area in Sq.Km.	Area covered in Sq.Km.	Percentage covered
Woodland	5.3	0.6001	12%
Grassland	9.8	1.6185	17%
Savannah	5.8	0.789	14%
Aquatic	8.5	4.75	55%

Fig 4: MAP SHOWING THE TRANSECT



STATISTICAL ANALYSIS

Standard parametric (Chi-Square and G-Test) and nonparametric (Mann-Whitney Test) tests were used (Bailey 1981, Snedcor 1982, Sokal and Rahlf 1969). All probability values are two tailed. Where two samples are significantly different as stated in the text, a significant difference of 0.05 level or at a higher level of significance is indicated.

5. RESULTS

5.1 CHITAL

A total of 1886 observation were made on Chital in various habitats during the 12 months period.

The population density of animals varied from one habitat type to another during different seasons. For the sake of convenience these variations have been expressed in terms of percentage and the expression 'percentage density' has been used in description.

The Chital was seen in all the types of habitats. The overall percentage density in the various habitats varied from 64.87 in woodland to 1.3 in aquatic (Appendix IV a). The percentage density in woodland habitat was significantly higher than that in other habitats for the whole year. Since the use of habitat appeared to be influenced by the seasonal change in habitat structure, seasonal variation in the utilization of each habitat was examined.

5.1.1 Seasonal variation in the habitat utilization.

WOODLAND

The percentage density of animals seen in woodland varied from 20.01 in October to 96.34 in June (Appendix IV a). Although there were seasonal variations in the utilization of woodland habitat ($P < 0.001$), the variation within the season

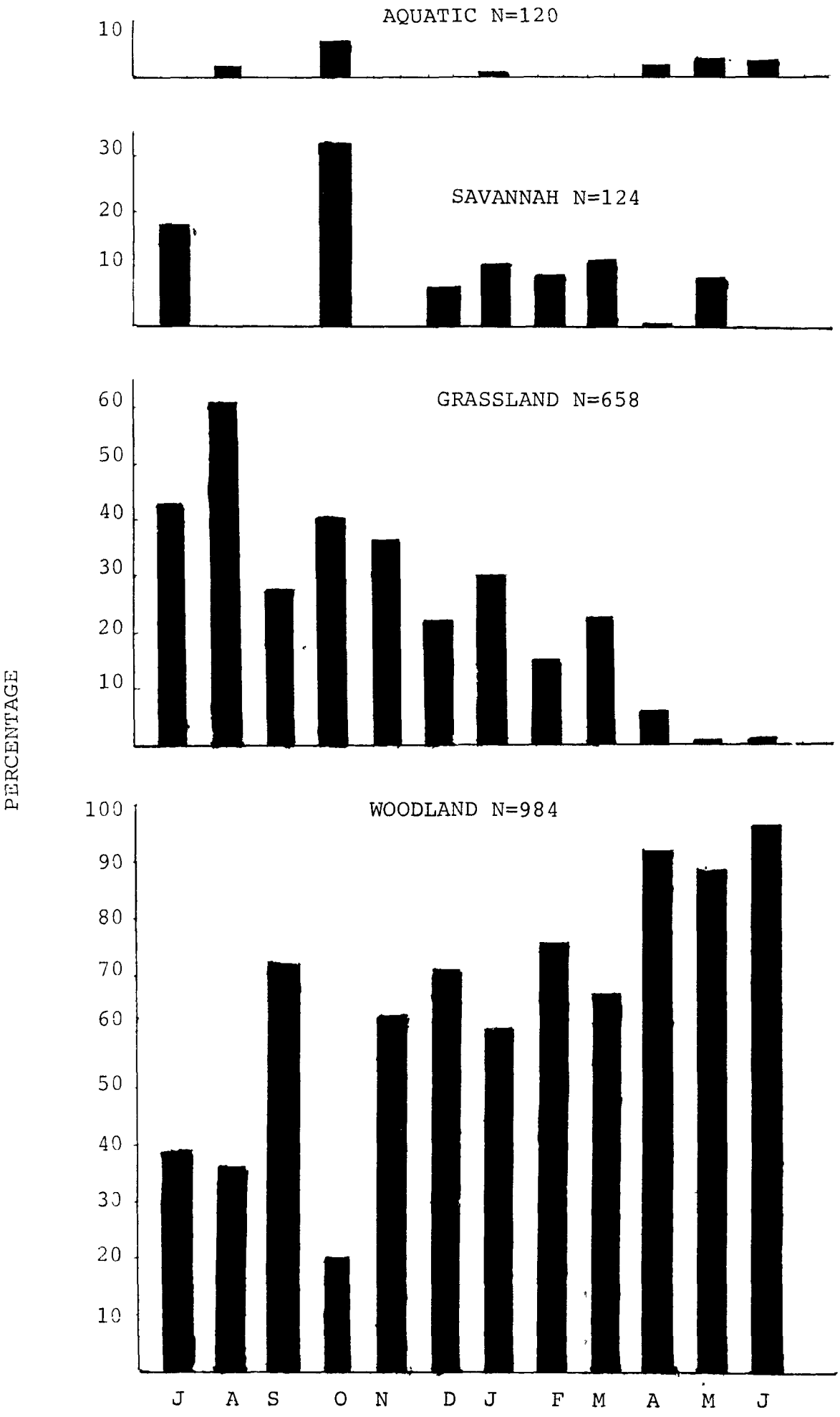


Fig 5: Periodic variation in percentage density of chital in different habitats.

was significant only during monsoon months i.e. July-September (Appendix V a). During winter and summer it was not significant. However, variation in the monsoon season shows a significant difference ($P < 0.001$) owing to increase of animals in the woodland habitat during September when grass cutting was allowed. This habitat appeared to be used more during the Summer. (Table 3).

GRASSLAND

The percentage density of the chital in grassland ranged from 0.58 in May to 61.83 in August. This habitat appeared to be used more during the monsoon months than in other seasons (Fig.5). In contrast to the woodland the percentage density of Chital in this habitat was slightly higher during the monsoon season than during the other two seasons. There was a significant difference in the utilization of this habitat in different months of each season ($P < 0.001$).

SAVANNAH

Although Chital were seen in the Savannah habitat throughout the year, except during August, September, November and June. The percentage density in this habitat was much lower than in woodland and grassland. Here the percentage density ranged from 0.77 in April to 33.36 in October

(Appendix IV a). This habitat was observed to be used more during monsoon period. (Table 3). Seasonal variation in the utilization of savannah was also significant ($P < 0.001$)

AQUATIC

The chital were seen in aquatic habitat during summer when this area gets dried up and beside these they were also seen in August when the villagers were engaged in grass cutting in terrestrial area which might have forced the animal to move in this habitat. During October when there was fire in savannah habitat the animals of that area move to the nearby aquatic habitat.

The percentage density in this habitat was less than 5 except in October when it reached 6.11 (Appendix IVa). Most of the Chitals grazed on the sprouting Paspalum in this habitat during October. They grazed mainly in the morning hours, since at other times they were disturbed by the villagers cutting the grass. No animal was seen in this habitat during the winter except in January when a doe was seen but after two days it was found dead near the same place. The percentage density of the Chital in monsoon and summer was almost the same (Table 3). Chital feed in the aquatic area when the grass sprout during monsoon. Also, when in summer the grasses in the terrestrial area get dried alongwith those of the aquatic area, the chital feed on the green grasses of the marsh area.

Table 3

Mean percentage density of chital sighted in various habitats during different seasons.

	Woodland	Grassland	Savannah	Aquatic
Monsoon	41.77	43.33	12.82	2.05
Winter	67.17	26.07	6.71	0.02
Summer	85.67	7.34	5.11	1.84

Table 4

Mean percentage density of sambar in various habitats during different seasons.

	Woodland	Grassland	Savannah	Aquatic
Monsoon	0	0	0	100
Winter	0	0	0	100
Summer	75	0	0	25

5.2 SAMBAR

Altogether 104 observations were made on the Sambar, of which 92% were in the aquatic area and 8% in the woodland habitat. The minimum and maximum percentage density in aquatic area was 100 during July to March i.e. monsoon to winter (Appendix IVb). But a significant shift was observed in the habitat preference during April to Junei.e. during summer when the percentage density inthe woodland habitat was 100 (Fig.6). The percentage density of Sambar if taken as an average for the whole year was significantly higher ($P < 0.001$) in the aquatic area than in the other three habitats. However, the shifts in different seasons appear to be due to the following factor. During the summer when the aquatic area dried up the animals moved towards the adjascent woodland area. They remained there till the onset of monsoon and then moved towards the aquatic area where they stayed for the rest of the year. Not even a single sambar was seen in other two habitats viz. grassland and savannah. (Table 4).

5.3 BLACKBUCK

Of the total 197 sightings of Blackbuck, 23% were in the grassland, 6% in savannah and 71% in the dried up aquatic area. No animal was seen in the woodland habitat. Not even a single Blackbuck was seen during September on any of the transects probably because the animals were disturbed by the movements of the villagers. The percentage density of Blackbuck in the

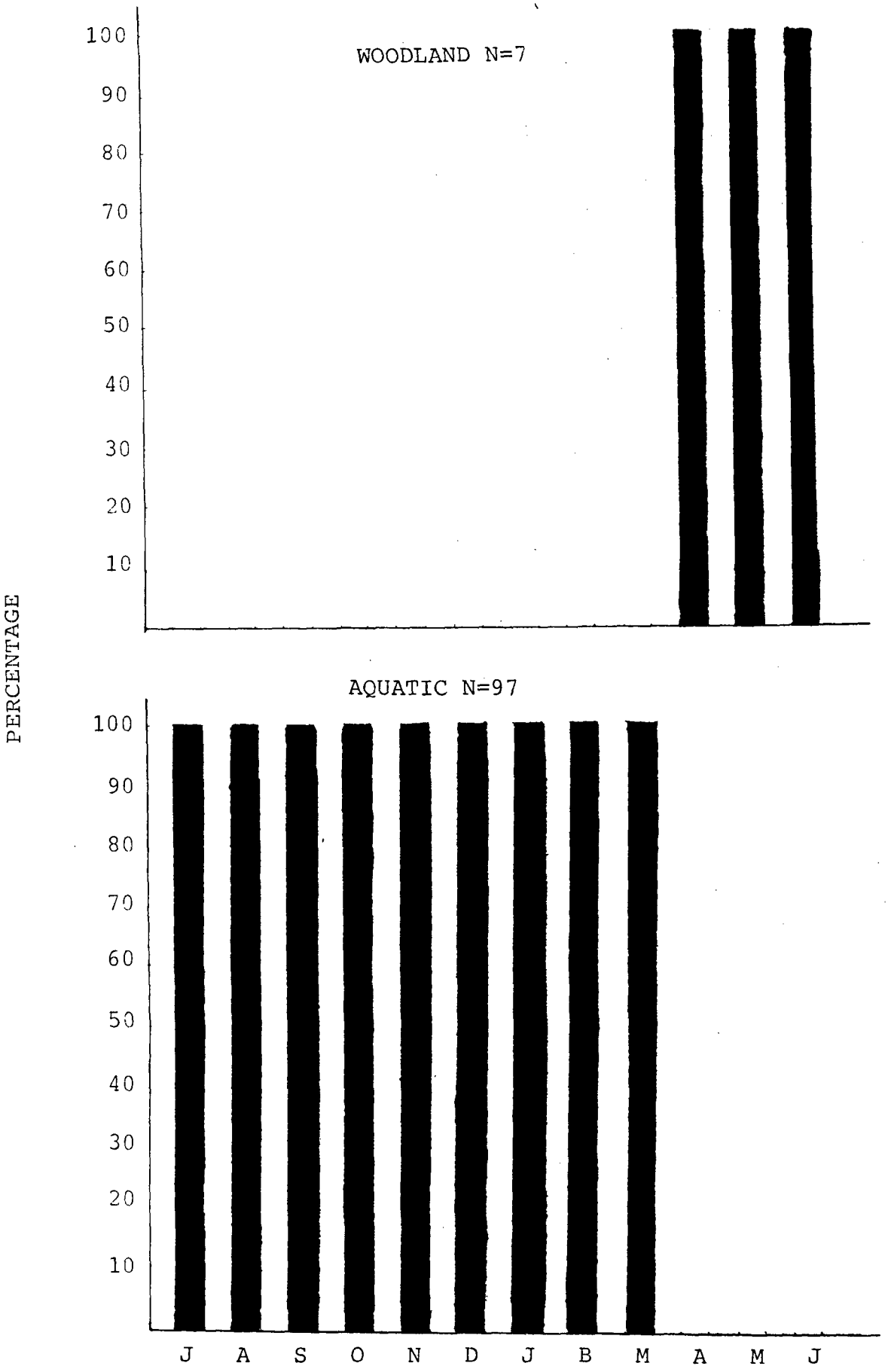


Fig 6: Periodic variation in percentage density of sambar in different habitats.

dried up area of aquatic habitat was significantly higher ($P < 0.001$) than that of other habitats.

5.3.1 Seasonal variation in the habitat utilization

GRASSLAND

The percentage density of the Blackbuck in grassland ranged from 11.02 in March to 100 in October. However, no animal was seen in this habitat during August and September (Appendix IV c). There were seasonl variations ($P < 0.001$), in the utilization of grassland habitat by the Blackbuck. The variation within the season is also significant ($P < 0.001$). Grassland appeared to be used most in the winter than in summer or during monsoon months (Table 5).

SAVANNAH

The animals were seen in the Savannah from October onwards upto January/February (Fig 7). It appears that they were attracted to this habitat to feed on the fresh sprout after fire broke out in October 1986. The cause of the fire, however, is still not known. The reason for the present of the animals in the savannah, observed during the two discontinuous months i.e. May and July, have not been understood and need further study.

AQUATIC

The percentage density of the Blackbuck in the aquatic

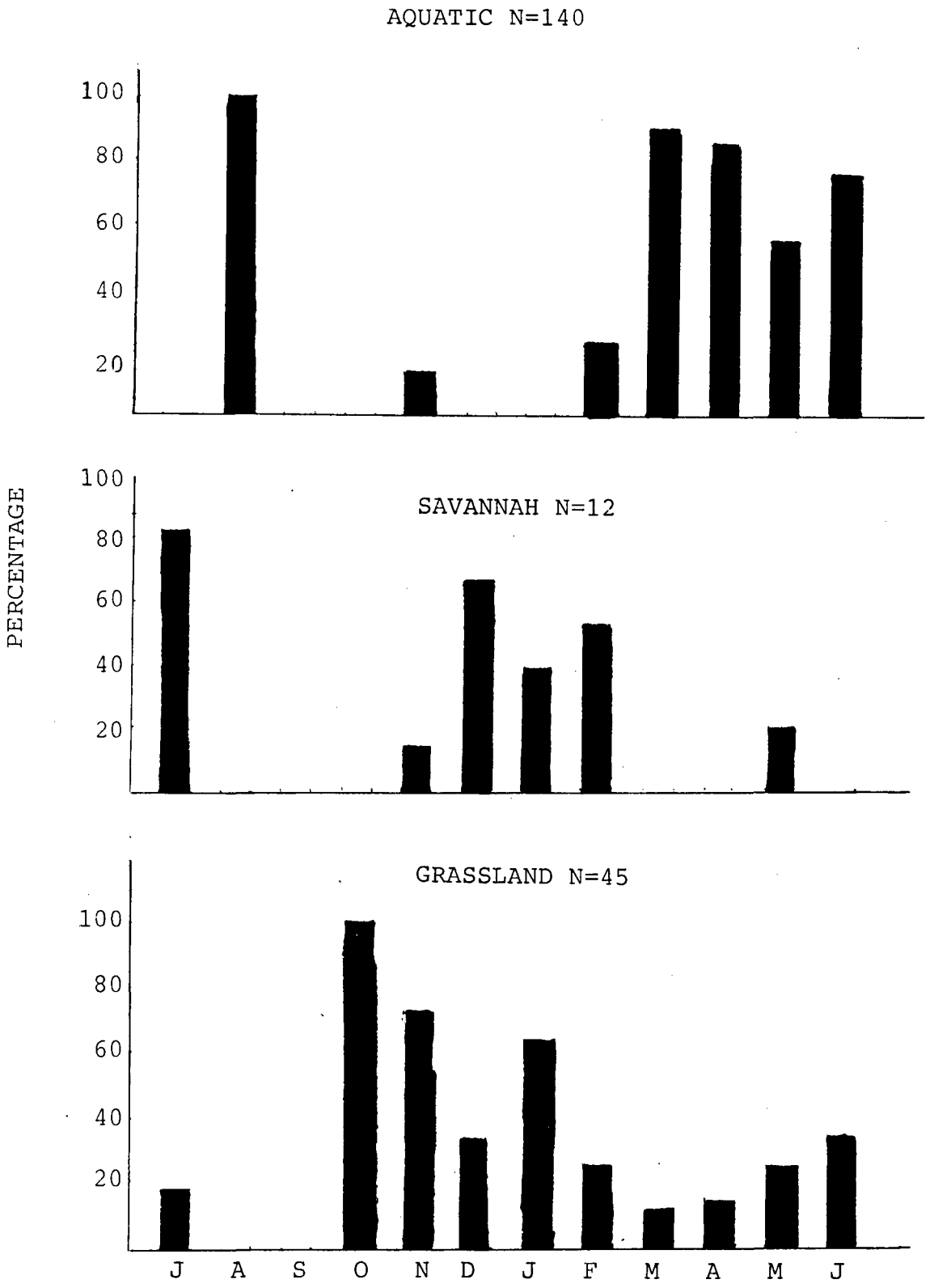


Fig 7: Periodic variation in percentage density of blackbuck in different habitats.

Table 5

Mean percentage density of Blackbuck in various habitat during different season

	Woodland	Grassland	Savannah	Aquatic
Monsoon	0	39.42	27.24	33.33
Winter	0	48.20	43.31	8.47
Summer	0	20.65	5.03	74.3

Table 6

Mean percentage density of Nilgai in various habitat during different season

	Woodland	Grassland	Savannah	Aquatic
Monsoon	34.33	23.13	25.77	16.74
Winter	34.47	15.57	37.63	12.30
Summer	32.64	7.60	51.92	7.8

habitat was significantly higher ($P < 0.001$) in summer than in any other season (Appendix V c). There was significant seasonal variation in the utilization of aquatic habitat ($P < 0.001$). The variation within the monsoon and winter months is also higher ($P < 0.001$) than that of the summer ($P < 0.05$). The percentage density inthe former season varied from 0 to 100 while in the latter from 55.97 to 88.97. Most of the Blackbuck were seen in dried up area of the aquatic habitat.

5.4 NILGAI

A total of 1979 observations were made on the Nilgai in the different habitats of the park during a period of 12 months. The overall percentage density in the various habitats ranged from 12.28 in the aquatic area to 38.44 in savannah.

5.4.1 Seasonal variation in habitat utilization

WOODLAND

Although the percentage density of the Nilgai in this habitat was significantly different ($P < 0.05$) throughout the year, its range was only from 20.14 in March to 45.24 in January (Appendix IV d). There was no seasonal variation in the utilization of the woodland habitat. The variation within the seasons is also less significant during winter and summer ($P < 0.05$) while in monsoon it was still more insignificant.

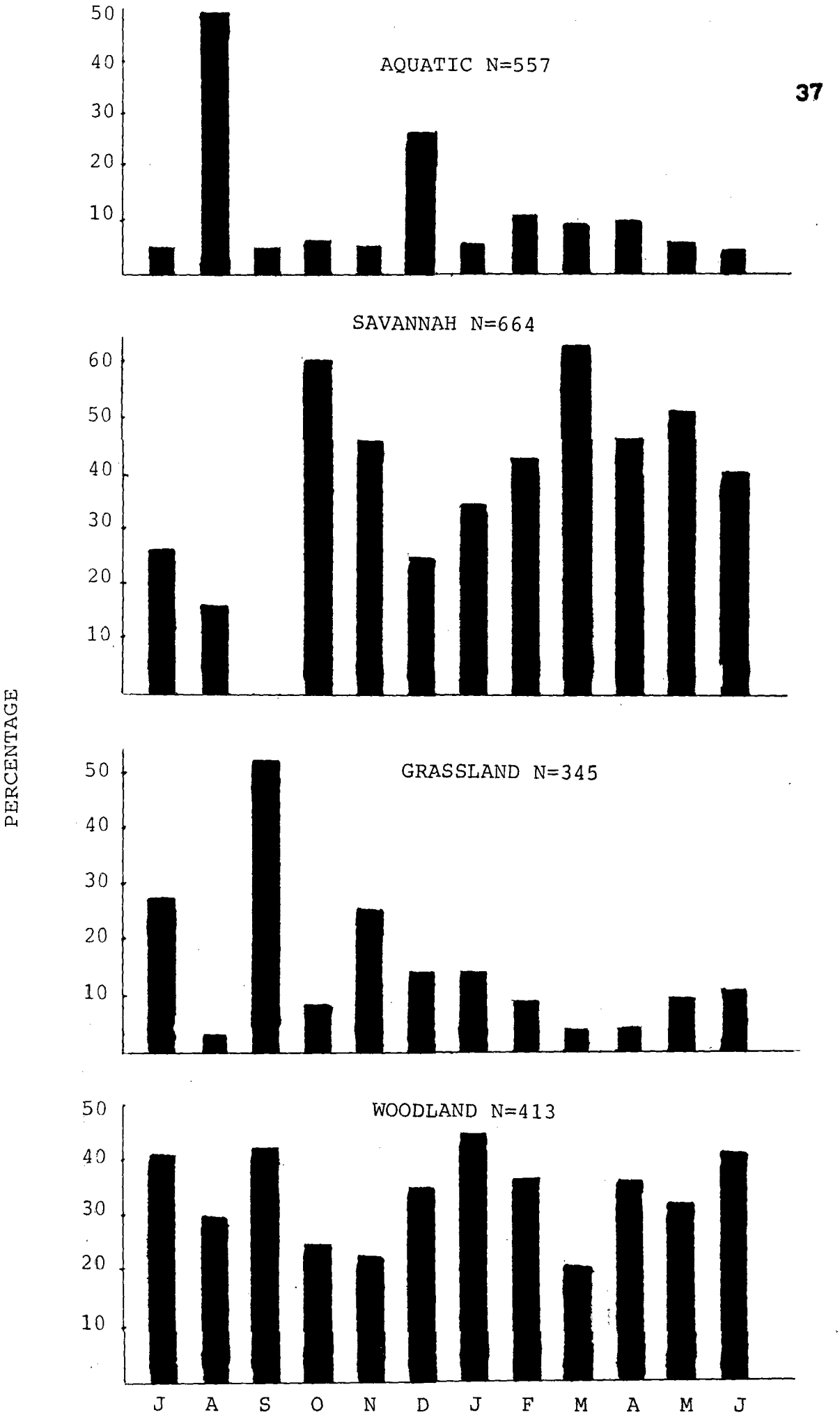


Fig 8: Periodic variation in percentage density of nilgai in different habitats.

GRASSLAND

The percentage density of Nilgai in the grassland varied from 3.65 in August to 52.54 in September (Appendix IV d). Although there was considerable seasonal variation ($P < 0.001$) in the utilization of the grassland habitat, the variation within the season is significant only during monsoon and winter. This habitat is utilized more during monsoon than in other seasons (Table 6).

SAVANNAH

In contrast to other habitats, savannah appeared to be used more by the Nilgai (Fig.8). The percentage density of Nilgai in this habitat varied from 16.25 in August to 65.49 in March. No animal was seen during September. There was a significant seasonal variation ($P < 0.001$) in the utilization of the savannah habitat. Like in the grassland, the variation within the season was significant only during monsoon and winter (Appendix V d). Savannah were utilized mostly in summer (Table 6) when grasses in the other areas were overgrazed. The Nilgai frequently graze on Desmostachya bipinnata in this habitat.

AQUATIC

Although some Nilgais were seen in aquatic habitat throughout the year, the percentage density was much lower in this habitat than in other habitats. The percentage density ranged from 4.5 in July to 50.76 in August (Appendix IV d)

There was considerable seasonal variation in the utilization of this habitat ($P < 0.01$). Variation during each of the three seasona was also significant ($P < 0.001$). This habitat appeared to be utilized more during monsoon when fresh grasses sprouted after the rain.

5.5 WILD BOAR

Altogether 327 observations of wildboar were made in all the habitats during 12 months. The overall percentage density varied from 0.44 in aquatic to 88.68 in woodland. The percentage density in the woodland habitat was considerably higher than in other habitats for the whole year.

5.5.1 Seasonal variation in the habitat utilization

WOODLAND

The percentage density of wild boar in the woodland habitat did not vary much throughout the year. It varied from 64.77 in May to 100 in September (Appendix IV e). There was seasonal variation in the utilization of this habitat. Variation during summer (March to June) was quite wide ($P < 0.05$). The sighting of animal was less frequent during May, probably due to the disporsal of Wild boar to the adjascent agricultural fields to feed on wheat. This habitat appeared to be used equally in all the three seasons (Table 7).

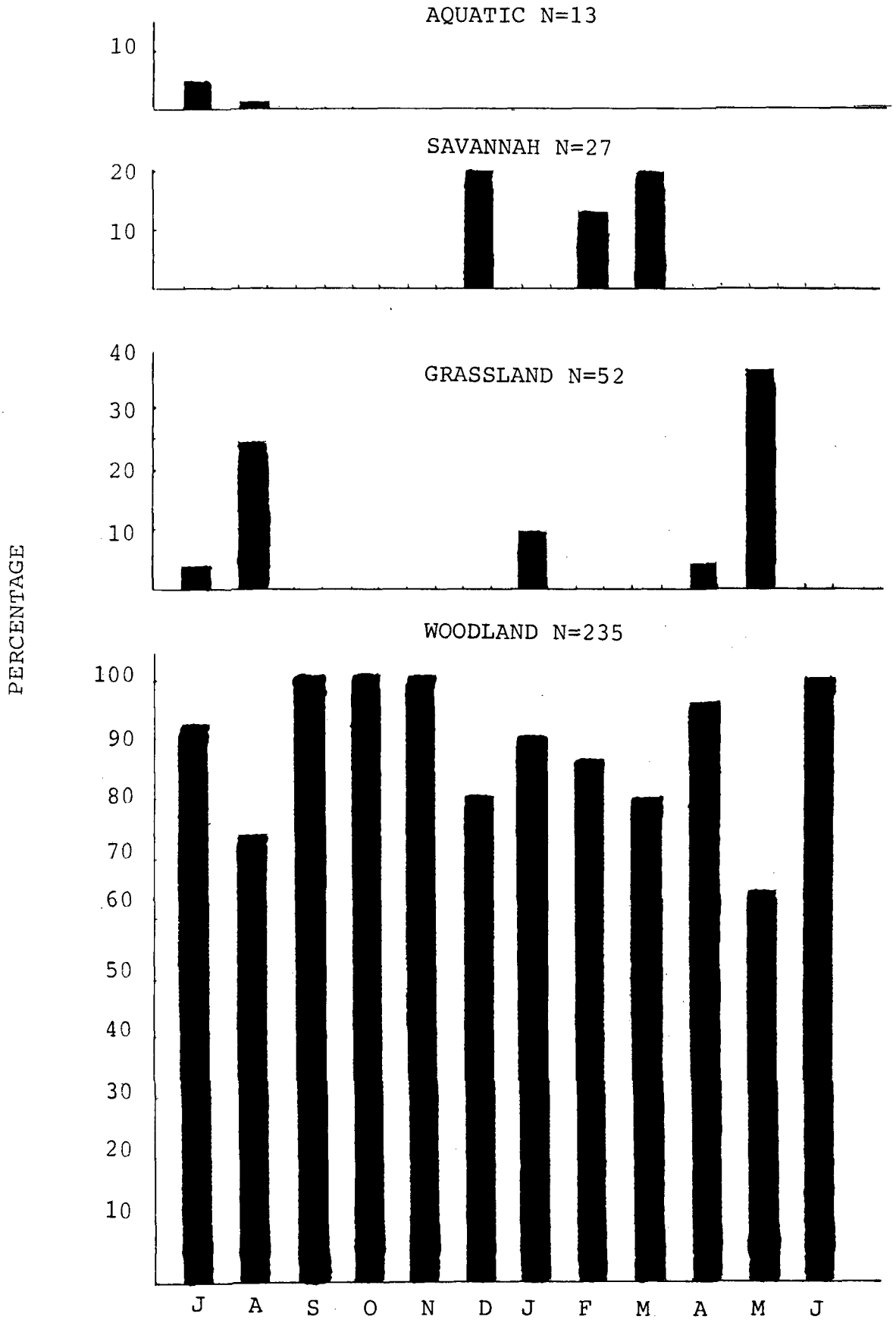


Fig 9: Periodic variation in percentage density of wildboar in different habitats.

GRASSLAND

The percentage density of wild boar in the grassland varied from 3.77 in April to 36.13 in May. They were sighted only during Monsoon (July and August) and summer (April and May). There was significant seasonal variation in their occurrence in this habitat ($P < 0.001$). The presence of wild boar during monsoon in this habitat is probably with corresponding abundance of grass after rain while its presence during summer cannot be explained.

SAVANNAH

Wild boar were seen in this habitat only during December, January, February and March. The percentage density of wild boar estimated in this habitat was quite high ($P<0.05$) in winter than in the rest of the year (Appendix V e). During this period wild boars were frequently seen feeding on the fruit of Zizyphus which was abundant in this habitat.

AQUATIC

As compared to other habitats, very few animals were seen in the aquatic area during day time, that too only in July and August (Fig.9). However, during the night hours they dug out rhyzome, of sedges and grasses from the marshes. The figures of night observation has not been considered in the text, as systematic observations during night were difficult.

Table 7

Mean percentage density of Wild Boar in various habitat during different season

	Woodland	Grassland	Savannah	Aquatic
Monsoon	91.21	7.43	0	1.34
Winter	89.47	3.13	0.17	0
Summer	85.36	9.97	4.88	0

Table 8

Mean percentage density of Feral cattle in various habitat during different season

	Woodland	Grassland	Savannah	Aquatic
Monsoon	4.38	22.87	71.02	1.71
Winter	21.80	40.89	36.14	1.14
Summer	12.77	52.52	27.08	7.59

5.6 FERAL CATTLE

Altogether 7502 observations of feral cattle were made in all the habitats during a period of 12 months. Feral cattle were seen in all the four habitats throughout the year. The overall percentage density varied from 3.48 in aquatic area to 44.75 in savannah (Appendix IV f). Like the other ungulates, feral cattle also show seasonal changes in habitat utilization.

5.6.1 Seasonal variation in the habitat utilization

WOODLAND

The percentage density of feral cattle in the woodland ranged from 1.64 in July to 42.77 in December. However, no animal was seen in this habitat during August and October. Considerable variation was noticed in the utilization of this habitat, both seasonally as well as within each season ($P < 0.001$) This habitat was utilized more in winter than in other seasons (Table 8).

GRASSLAND

The percentage density of feral cattle in winter and summer was comparatively higher in this habitat than in other habitats. The percentage density ranged from 7.18 in October to 58.18 in April. Like the woodland habitat, there was significant seasonal variation ($P < 0.001$) in the utilization

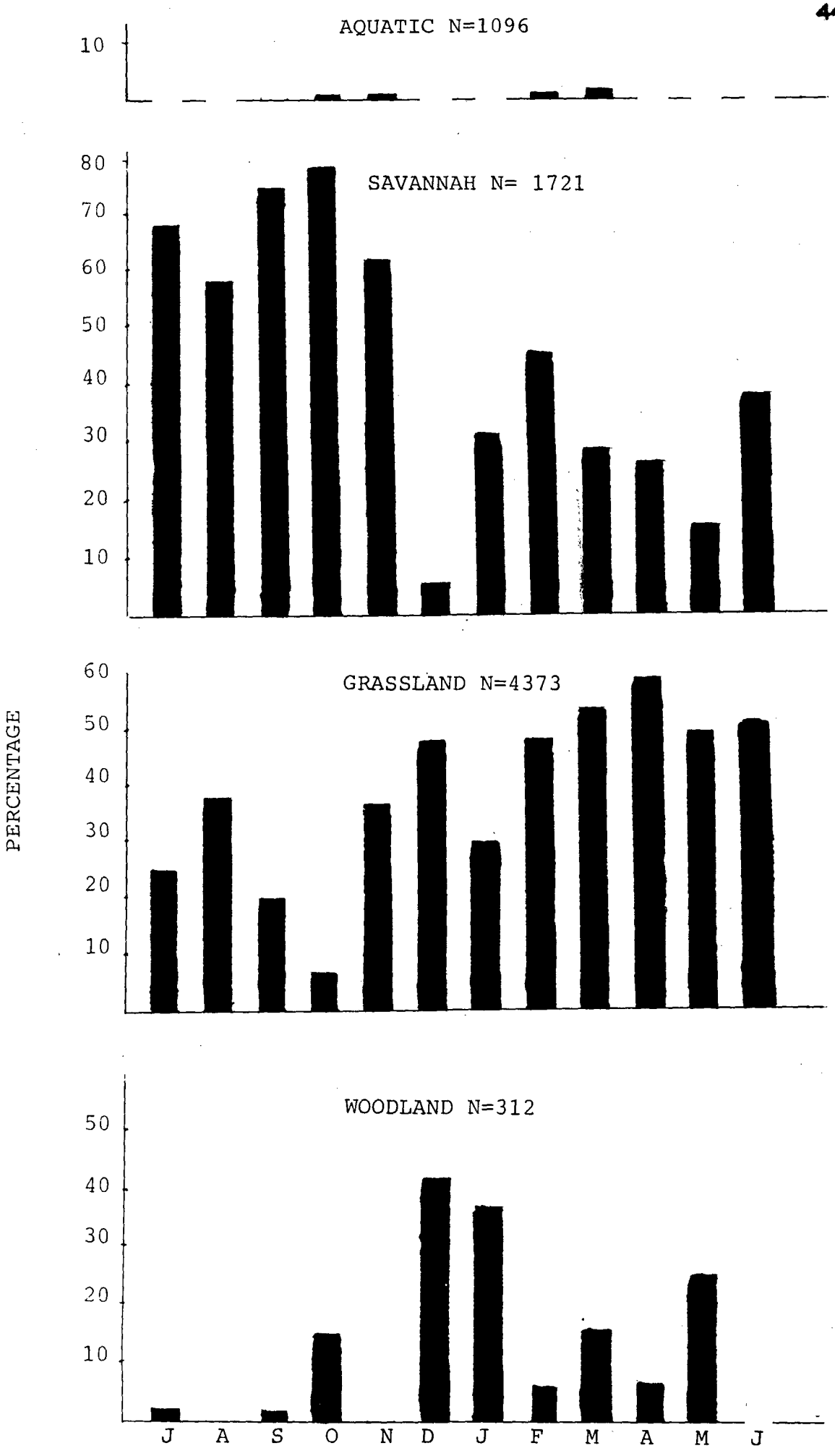


Fig 10: Periodic variation in percentage density of feral cattle in different habitats.

of this habitat also. The variation within the season was significant only during monsoon, i.e. July to October. (Appendix V f). The percentage density during monsoon varied from 7.18 in October to 36.95 in August. The poor percentage in October was because of the disturbance by the villagers. There was not much variation in the utilization of this habitat by the feral cattle during winter and summer seasons. This habitat appeared to be used most during summer (Table 8).

SAVANNAH

As compared to the other three habitats savannah was the most preferred habitat (Table 8). The percentage density of the feral cattle in savannah habitat varied from 5.75 in December to 78.36 in October. There was significant seasonal variation ($P < 0.01$) in the utilization of this habitat. The variation within the season was significant in winter ($P < 0.001$) and summer ($P < 0.05$). The percentage density of the feral cattle in the savannah habitat shows a decreasing trend from March to May but from June it shows an increasing trend. There was no significant variation within the monsoon months. Of all the three seasons, this habitat was used mostly during the monsoon (Fig.10).

AQUATIC

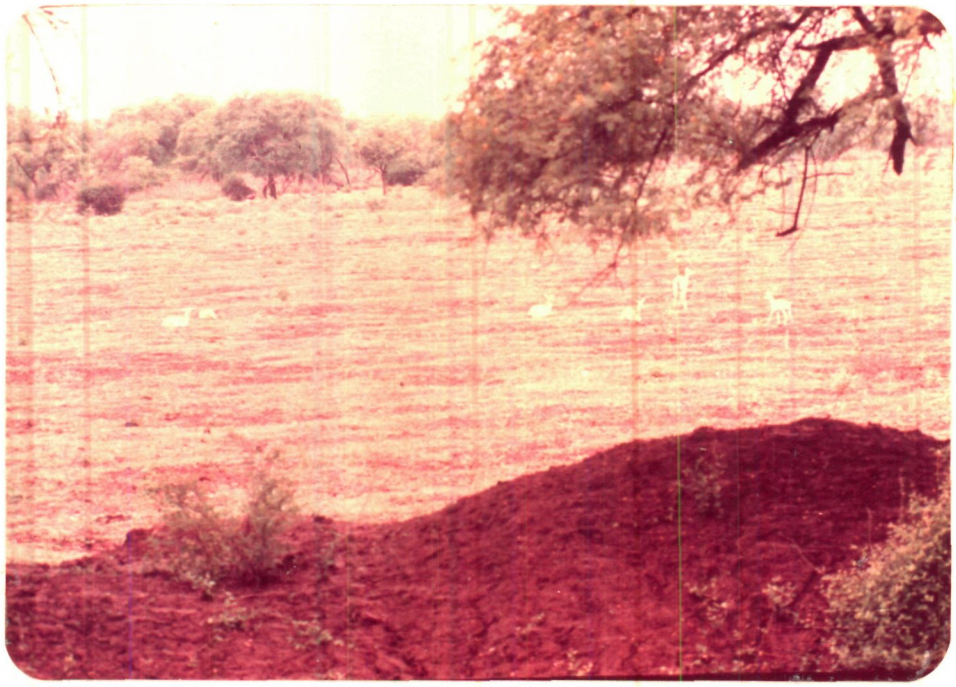
Although feral cattle were seen in the aquatic area throughout the year, the percentage density in this habitat was

much lower than in the other three habitats. The percentage density of the feral cattle varied from 0.31 in November to 10.44 in May (Appendix IV f). No animal was seen in this habitat during September. There was wide seasonal variation in the use of this habitat ($P < 0.001$). Variation during monsson was less significant ($P < 0.05$) than in summer ($P<0.001$). However, there was not much variation during winter. The percentage density shows an increasing trend from March to May, when most of the feral cattle were seen in this habitat during the late evenings, either grazing on the green Paspalum or drinking water. Of all the three seasons, this habitat was used most during summer (Table 8).

6. DISCUSSION

The Chital in Keoladeo National Park utilizes a variety of habitats, but showed during the study period, certain seasonal trends as has been reported by Mishra (1982) in the Chitwan National Park, Nepal. The woodland was utilized more than the other types. They remained in the woodland habitat longer in the winter and summer as compared to the monsoon season. In monsoon season they spent more time feeding inthe grassland than in the woodland because of abundance of grasses in the former habitat. On the other hand, in summer they spent most of the time browsing in woodland, as the grasses had dried in the grasslands. A similar observation was made by Berwick (1974) in the dry tropical forest of Gir where the Chital was a primary browser during the dry season. Brander (1923) and Chandran et al (1977) reported that Chitals have a tendency to congregate around human habitats. Based on observation in Chitwan National Park, Mishra (1982) concluded that the change brought in the vegetation by man and nature appears to provide a good habitat for Chital. Ables (1974) describes the Chital as a plastic species capable of considerable adaptation.

The Chital in Chitwan National Park, Nepal according to Mishra (1982) shows a seasonal pattern of segregation of sexes during the winter months (November to January) when all



BLACKBUCK IN THE DRIED UP AQUATIC AREA

SAMBAR BROWSING AND GRAZING IN THE MARSH

male groups are formed while groups of females with young foraged separately. The same pattern has been observed in Keoladeo National Park. Another observation by the author is the coincidence of the period of segregation of sexes with the period when most of the males had their antlers in velvet. It has also been observed that the males with velvet antler spent most of the time in the woodland. Clutton et al (1982) also reported that different habitat were preferred by the two sexes of the Red deer in a particular season.

While food availability is the major factor which influences the habitat selection (Pandey et al 1986, Collins and Urness 1983), climatic factors such as temperature also play a vital role. The number of animals seen in shady areas increased when the temperature was the maximum (48°C) during summer and minimum (2°C) during winter. Ables (1974) also feels that Chital need overhead cover for shelter from sun. However, the amount of rainfall does not seem to affect the behaviour of Chital at Keoladeo National Park in regard to overhead cover.

Schaller (1967) found it extremely difficult to observe the sambar for long duration as they preferred dense bushes and were very fearful and shy. But the case is entirely different at Keoladeo National Park where the sambar are frequently seen in the aquatic area especially in the winter and rainy season.

The sambar prefers the dense forest (Berwick 1972) Mishra 1982, Lahan and Sonawal 1973, Brander 1923). Berwick (1972) reported that sambar are rarely seen in the open hilly savannah of the Gir forest, Gujarat while Chandran et al (1977) reported that Sambar were frequently seen in open scrub of Mudumalai.

During day time they were mostly seen in Keoladeo National Park resting on the mounds. These mounds are surrounded by water. Only during early morning and late evening they come down from the mound to graze on Paspalum distichum and Ipomoea aquatica. Acacia nilotica which was planted on the mounds provide them not only cover but also browsing material. Their habitat preference is influenced by two factors viz. cover and water. This conclusion is also supported by Johnsingh (1980) and Ramachandran et al (1986). But in the beginning of summer when the area gets dried up, the animals move towards the adjacent woodland. Again on the onset of monsoon they return to their aquatic habitat. This seasonal shift from woodland to areas covered with rain water during monsoon is also reported by Richardson (1972) from Texas. According to him rain serves to increase the abundance of grasses and sedges and sambar is attracted there. Other plausible explanations for Sambar's preference for woodland during summer are as follows:

1) Pregnant hinds need high protein diet which is available from the diverse vegetation in the woodland and is in poor supply in dry grassland.

2) Feeling of insecurity on the mounds when the surrounding water dries up.

3) Higher level of humidity in woodland cover prevents the body from heat and dehydration.

The return of the animals to the marshes during monsoon is probably because the hinds find it safer to drop the fawns on the mounds which are protected from predators by surrounding water.

Blackbuck as reported by earlier workers (Daniel 1967, Schaller 1967, Nair 1977) prefers grassland habitats the most in Keoladeo National Park. However, there was noticeable seasonal shifts on their habitat preference, especially for grassland, savannah and dried up aquatic habitats. Brander (1923) found Blackbuck on open grass maidan surrounded by forest. Prasad and Rao (1984) studied the habitat preference of Blackbuck in Andhra Pradesh and they found that it mainly prefers the open plain grassland.

Blackbuck were mostly seen grazing on the fresh sprout of Vetiveria zizanioides and Desmostachya bipinnata soon after the outbreak of fire in mid October 1986. Blackbuck's preference

A HERD OF NILGAI IN DRIED UP MARSH

CROP FIELDS ADJACENT TO THE PARK BOUNDARY

for Desmostachya bipinnata is also supported by Goyal and Boha (1985) on the basis of their study in Bishnoi inhabitated areas of Rajasthan. It has been observed during the course of the present study that Blackbuck leaves the area when the grass grows taller than 60 cm.

Since the study was conducted in a year when the rainfall was only 375mm against the normal 600mm, most of the aquatic area was drying up early in February, whereas it happens in April if rainfall is normal. During the period of study, some of the aquatic areas were bulldozed by the forest department for controlling the excessive growth of the weed Paspalum distichum. As a result a few open patches were created where the grass started sprouting. Most of the Blackbuck were seen grazing on sprouting grasses in those patches.

An interesting observation on Blackbuck behaviour the adaptive significance of which is not clear, is its grazing or lying in the open in the hottest part of the day in summer when plenty of cover is available. The same phenomenon has been reported by Prasad (1985) and Rahmani (personal communication).

Nilgai according to Prater (1965) prefers hills sparsely dotted with trees or land or undulating plains covered with grass and patches of scrub. It avoids dense forest and frequently enter cultivation. This statement confirms the earlier report of Brander (1923) and the still

earlier report of Blandford (1888). During the present study, however, the seasonal variation in the nilgai's habitat preference was found to be different.

The Nilgai in Keoladeo National Park shows a preference of habitat more or less similar to the one described by Berwick and Jordon (1971) and Berwick (1974) from Gir forest who described Nilgai existing equally well in the most dense and in the most open of vegetation.

The number of animals and the frequency of their presence in different habitats observed in different seasons indicates that although savannah is the most preferred habitat, the nilgai is not wary of woodland in Keoladeo National Park as found elsewhere.

Adult males were frequently seen holding on to their territories in the woodland during the rutting season, which is Keoladeo National Park has been from October to February. Why the males show a comparative preference for the woodland habitat during the rutting periods is not clear. The young ones are born during summer and early rainy season i.e. May to July. The young ones are dropped mostly in the woodland habitat.

The Nilgai with their young calves were seen in the savannah habitat during winter, grazing on the grasses.

THE WILD BOAR SCAVENGING ON THE
GARBAGE BEHIND THE FOREST LODGE

THE MARSH AREA 'PLOUGHED'BY WILDBOAR

The tall Vetiveria zizanioides which was saved from the fire on 1986 served as a protective cover for the calves. The Nilgai were seen feeding on grasses of the burnt area only in the late evenings. The reasons for their preferring savannah habitat during summer seem to be the non-availability of grasses elsewhere during this period. The study also records that they spent most of the afternoons under the dense cover of the woodland adjacent to aquatic area. Some animals however, were seen to move towards the aquatic area during evenings.

During winter a few Nilgais went out of the National Park through the broken boundary wall and also grazed on the wheat and chana crops cultivated in the villages around the park. They raid the crop field mostly during the night. Robert (1977) and Brander (1923) also have reported nilgai raiding agricultural crops.

A few detailed studies have been done on the European Wild Boar (Maryse 1986). But only stray information is available on the Wild boar in our country through the work of Schaller (1966) Prater (1965), Chandran et al (1977), Lahon and Sonowal (1973) and Brander (1923).

The present study reveals that the Wildboar spends the greater part of the day in the woodland probably for cover. Most of the time they were encountered while

lying under the bush. They used to come out only during night or when they are disturbed. They were seen uprooting the sedges and grass in the marshy area of the adjacent woodland habitat while feeding at night on the tubers of Scirpus tuberousus and Cyperus rotundus. This happened mainly during February-April. Such a behaviour has already been reported by Maryse (1986) in European Wild Boar and Brander (1923). However, Chandran et al (1977) have not observed such a behaviour although they reported the animals preference for marshy habitat. The uprooting behaviour is restricted to marshy area mainly because it is easier to dig in the soft soil.

A few adult boars were seen inside the aquatic area, feeding on Paspalum distichum during the rainy season, whereas, in the winter they were seen in the savannah habitats, feeding mainly on the fruit of Zizyphus jujuba which grows there in abundance.

When the marshes dried up during summer and the soil hardened the Wildboar went out of the National Park through the drainage outlets in the boundary wall to the adjacent crop fields outside the park to feed mainly on wheat. This is indicated by the presence of wheat grains in the droppings. The Wild Boar are hunted by the villagers in order to protect their crops. The damage to crop by

A HERD OF FERAL CATTLE GRAZING IN GRASSLAND

FERAL CATTLE ATTRACTED TO THE AQUATIC AREA BULLDOZED AFTER DRYING UP.

Wild Boar is a regular phenomenon throughout its distribution range as reported by Prasad et al (1978) Green (1981), Chandran et al (1977) and Maryse (1986). A few Wild Boar were also seen feeding on the garbage behind the Forest Lodge.

No detailed study has been done on any aspect of feral cattle in our country. Gee (1958) reported that the feral cattle of Bharatpur were quite similar to that in Britain. Dang (1959) gave some information on the distribution of feral cattle in western Uttar Pradesh.

The most preferred habitat of feral cattle inside the Keoladeo National Park is grassland and savannah. The latter habitat was mostly preferred after the fire in 1986. Similar observations were made by other workers, on chital (Mishra 1982), white tailed deer (Robert et al 1986), mule deer and elk (Singh 1979). In summer (during the study period) when the aquatic area dried up feral cattle were seen grazing in this habitat while during the remaining part of the year only a few adult males were seen inside the aquatic area feeding on Paspalum distichum like the buffalos which used to forage in the marshes. The number of animals was high in the woodland during winter (December-January) which coincides with the peak calving period of the

THE BREACHED BOUNDARY WALL OF THE PARK

THE BROKEN WATER INLETS THROUGH
THE BOUNDARY WALL

cattle. Feral cattle in the study area are mostly gragarious and only the preganant cows leave the herd and move towards the woodland to drop their young. Most of the calves were seen under Salvadora persica. Saline patches covered with Prosopis juliflora were used by feral cattle for the resting.

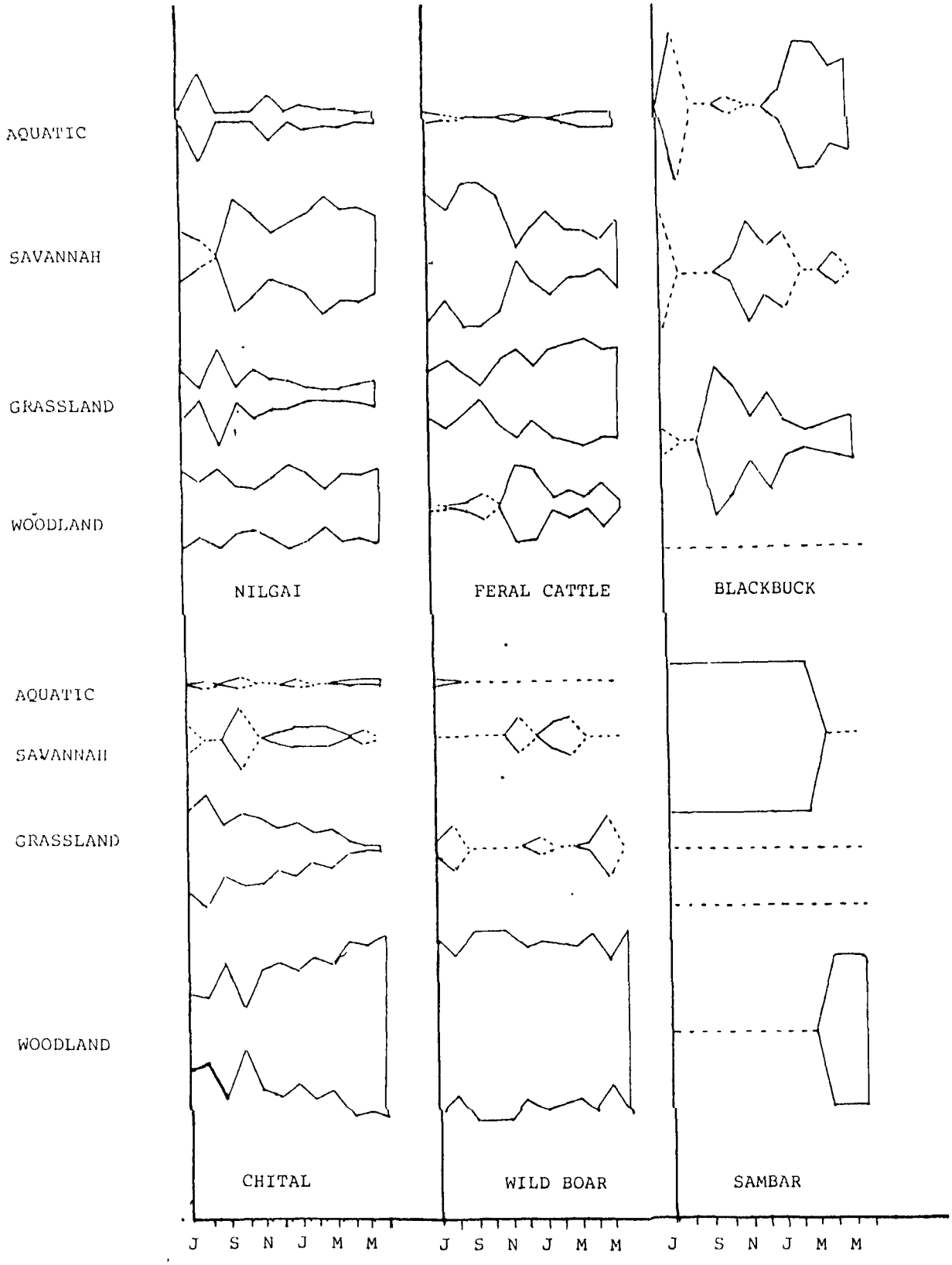


Fig 11 : Habitat utilization by different species at a glance

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Appendix I

A list of common plants found in the Keoladeo National Park, Bharatpur

TREES

1. Acacia nilotica
2. Acacia leucophloea
3. Albizzia lebbeck
4. Azadirachta indica
5. Balanites roxburghii
6. Cassia fistula
7. Cordia dichotoma
8. Crataeva nurvala
9. Dalbergia sissoo
10. Delonix regia
11. Dichrostachys cinerea
12. Diospyros cordifolia
13. Ehretia aspera
14. Ficus benghalensis
15. Ficus glomerata
16. Ficus religiosa
17. Mitragyna parvifolia
18. Phoenix sylvestris
19. Prosopis juliflora
20. Prosopis spicigera
21. Randia dumatorium
22. Salvadora persica
23. Salvadora oleoides

40. Eclipta prostrata
41. Eichhornia crassipes
42. Euphorbia hirta
43. Euphorbia hypercifolia
44. Evolvulus alsinoides
45. Gnaphalium indicum
46. Gnaphalium luteo-album
47. Gomphrena celosioides
48. Grangea maderaspatana
49. Gynandropsis gynandra
50. Hydrolea zeylanica
51. Hygrophila polysperma
52. Indigofera cordifolia
53. Indigofera tinctoria
54. Indigofera trita
55. Jussiaea perennis
56. Laggera aurita
57. Leucaena leucocephala
58. Leucas urticaefolia
59. Lindernia crustacea
60. Lindernia parvifolia
61. Merremia emerginata
62. Monochoria vaginalis
63. Nicotiana plumbaginifolia
64. Nothosaerva brachiata
65. Oldenlandia corymbosa

66. Oldenlandia aspera
67. Pedalium murex
68. Peristrophe bicaliyculata
69. Phyla nodiflora
70. Phyllanthus fraternus
71. Phyllanthus simplex
72. Pluchea lanceolata
73. Plumbago zeyalanica
74. Polycarpon prostratum
75. Potentilla supina
76. Pulicaria crispa
77. Pupalia lappacea
78. Ruellia tuberosa
79. Rungia pectinata
80. Rumex dentatus
81. Salsola baryosma
82. Sesbania bispinosa
83. Sida rhombifolia
84. Sonchus arvensis
85. Solanum surattense
86. Suaeda fruticosa
87. Teramnus labialis
88. Tribulus terrestris
89. Trichosanthes cucumerina
90. Trianthema portulacastrum
91. Vernonia cinerea

92. Vicia sativa

93. Vicoa indica

94. Vigna trilobata

95. Withania somnifera

96. Xanthium strumarium

GRASSES

1. Cynodon dactylon

2. Dactyloctenium aegypticum

3. Desmostachya bipinnata

4. Dicanthium annulatum

5. Echinochloa colonum

6. Eragrostis Spp.

7. Eriochloa procera

8. Fimbristylis spp.

9. Iseilema laxum

10. Oryza spp.

11. Panicum antidotale

12. Paspalum distichum

13. Paspalidium punctatum

14. Pseudoraphis spinescens

15. Sporobolus helvolus

16. Vetiveria zizanioides

AQUATIC

1. Aponogeton natans

2. Astercantha longifolia
3. Ceratophyllum demersum
4. Cyperus alopecuroides
5. Cyperus rotundus
6. Eleocharis plantaginea
7. Hydrilla verticillata
8. Ipomoea aquatica
9. Lemna paucicostata
10. Marsilea sp.
11. Najas minor
12. Neptunea oleraceae
13. Nymphaea nouchali
14. Nymphaea stellata
15. Nymphoides cristatum
16. Nymphoides indicum
17. Polygonnum limbatum
18. Polygonnum plebeium
19. Potamogeton crispus
20. Potamogeton nodosus
21. Sagittaria quayanensis
22. Sagittaria sagittifolia
23. Scirpus articulatus
24. Scirpus littoralis
25. Scirpus tuberosus
26. Spirodela polyrrhiza
27. Typha angustata
28. Wolffia sp.

Appendix II

A list of mammals occuring in the Keoladeo National Park,Bharatpur.

1.	*Macaca mulatta*	:	Rhesus macaque
2.	*Panthera pardus*	:	Leopard
3.	*Felis chaus*	:	Jungle cat
4.	*Felis viverrina*	:	Fishing cat
5.	*Paradoxurus hermaphroditus*	:	Common palm civet (Toddy cat)
6.	*Viverricula indica*	:	Small Indian civet
7.	*Herpestes auropunctatus*	:	Small Indian mongoose
8.	*Herpestes edwardsi*	:	Common mongoose
9.	*Hyaena hyaena*	:	Striped hyaena
10.	*Vulpes bengalensis*	:	Indian fox
11.	*Canis aureus*	:	Jackal
12.	*Lutra perspicillata*	:	Smooth Indian otter
13.	*Suncus murinus*	:	Musk shrew
14.	*Pteropus giganteus*	:	Flying fox
15.	*Scotophilus heathi*	:	Common yellow bat
16.	*Hipposideros fulvus*	:	Bicoloured leaf-nosed bat
17.	*Funambulus pennanti*	:	Five striped palm squirrel
18.	*Hystrix indica*	:	Indian porcupine
19.	*Tatera indica*	:	Indian gerbille
20.	*Bandicota bengalensis*	:	Indian mole-rat
21.	*Vandeleuria oleracea*	:	Longtailed tree mouse

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22. Lepus nigricollis ruficaudatus : Rufoustailed hare

23. Boselaphus tragocamelus : Nilgai

24. Bos indicus : Feral cattle

25. Antilope cervicapra : Blackbuck

26. Axis axis : Chital

27. Axis porcinus : Hog-Deer

28. Cervus unicolor : Sambar

29. Sus scrofa : Indian wild boar

Appendix III

Population of the ungulates in Keoladeo National Park during 1987

Species	Estimated
Chital	230-260
Feral cattle	900-950
Nilgai	160-180
Blackbuck	18-20
Wild boar	200-250
Sambar	20-22
Hog deer	1-2

Appendix IV A : Population density of chital (expressed in terms of %)in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	123	29	1.2002	24.16	38.98	86	3.237	26.7	43.08	8	0.7354	11.11	17.92	Q	9.5	0	0
AUG	91	15	1.2002	12.49	36.05	69	3.237	21.42	61.83	0	0.7354	0	0	7	9.5	0.73	2.10
SEP	51	25	1.2002	20.82	72.06	26	3.237	8.07	27.93	0	0.7354	0	0	0	9.5	0	0
OCT	69	7	1.2002	5.83	20.01	38	3.237	11.8	40.5	7	0.7354	9.72	33.36	17	9.5	1.78	6.11
NOV	38	15	1.2002	12.49	63.62	23	3.237	7.14	36.37	0	1.578	0	0	0	9.5	0	0
DEC	132	66	2.4004	27.49	70.09	57	6.474	8.85	22.56	9	3.156	2.88	7.34	0	19	0	0
JAN	206	80	2.4004	33.32	59.77	107	6.474	16.61	29.79	18	3.156	5.76	10.33	1	19	0.05	0.08
FEB	259	151	2.4004	62.9	75.21	84	6.474	13.04	15.59	24	3.156	7.69	9.19	0	19	0	0
MAR	318	149	2.4004	62.07	66.08	135	6.474	20.96	22.31	34	3.156	10.89	11.59	0	19	0	0
APR	239	182	2.4004	75.82	92.00	30	6.474	4.65	5.64	2	3.156	0.64	0.77	25	19	1.3	1.57
MAY	256	182	2.4004	75.82	88.27	1	6.474	0.5	0.58	22	3.256	6.97	8.11	51	19	2.6	3.02
JUNE	104	83	2.4004	34.57	96.34	2	6.474	0.31	0.86	0	3.256	0	0	19	19	1	2.78
TOTAL	1886	984		447.78	778.48	658		148.05	367.04	124		55.66	98.61	120		7.46	15.06
$\bar{X}$	157.16	82		37.31	64.87	54.83		11.67	25.58	10.33		4.63	8.21	10		0.62	1.30
SD	94.06	67.53		25.26	23.35	42.22		8.41	18.42	11.50		4.55	9.86	15.74		0.87	1.92

Appendix IV B : Population density of sambar (expressed in terms of %) in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density (A)	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density (A	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	11	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	11	9.5	1.15	100
AUG	5	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	5	9.5	0.52	100
SEP	9	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	9	9.5	0.94	100
OCT	10	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	10	9.5	1.05	100
NOV	13	0	1.2002	0	0	0	3.237	0	0	0	0.578	0	0	13	9.5	1.36	100
DEC	27	0	2.4004	0	0	0	6.474	0	0	0	3.156	0	0	27	19	1.42	100
JAN	15	0	2.4004	0	0	0	6.474	0	0	0	3.156	0	0	15	19	6.78	100
FEB	6	0	2.4004	0	0	0	6.474	0	0	0	3.156	0	0	6	19	0.31	100
MAR	1	0	2.4004	0	0	0	6.474	0	0	0	3.156	0	0	1	19	0.05	100
APR	2	2	2.4004	0.83	100	0	6.474	0	0	0	3.156	0	0	0	19	0	0
MAY	3	3	2.4004	1.24	100	0	6.474	0	0	0	3.156	0	0	0	19	0	0
JUNE	2	2	2.4004	0.83	100	0	6.474	0	0	0	3.156	0	0	0	19	0	0
TOTAL	104	7		2.9	300	0		0	0	0		0	0	97		13.58	900
$\bar{X}$	8.66	0.58		0.24	25	0		0	0	0		0	0	8.08		6.79	75
SD	7.40	1.08		0.44	45.22	0		0	0	0		0	0	8.02		0.55	44.61

Appendix IV C : Population density of blackbuck (expressed in terms of %) in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	4	0	1.2002	0	0	2	3.237	0.62	18.28	2	0.7354	2.77	81.71	0	9.5	0	0
AUG	8	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	8	9.5	0.84	100
SEP	0	0	1.2002	0	0	0	3.237	0	0	0	0.7354	0	0	0	9.5	0	0
OCT	4	0	1.2002	0	0	4	3.237	1.24	100	0	0.7354	0	0	0	9.5	0	0
NOV	16	0	1.2002	0	0	10	3.237	3.1	72.94	1	1.578	0.63	14.82	5	9.5	0.52	12.23
DEC	2	0	2.4004	0	0	1	6.474	0.15	32.6	1	3.156	0.31	67.39	0	19	0	0
JAN	17	0	2.4004	0	0	13	6.474	2.01	61.46	4	3.156	1.26	38.53	0	19	0	0
FEB	9	0	2.4004	0	0	2	6.474	0.31	25.83	2	3.156	0.63	52.5	5	19	0.26	21.66
MAR	24	0	2.4004	0	0	1	6.474	0.15	11.02	0	3.156	0	0	23	19	1.21	88.97
APR	38	0	2.4004	0	0	2	6.474	0.31	14.09	0	3.156	0	0	36	19	1.89	85.9
MAY	40	0	2.4004	0	0	5	6.474	0.77	24.60	2	3.156	0.63	20.12	33	19	1.73	55.27
JUNE	35	0	2.4004	0	0	5	6.474	0.77	32.90	0	3.156	0	0	30	19	1.57	67.09
TOTAL	197					45		9.43	393.72	12		6.23	275.07	140		8.02	431.12
$\bar{X}$	16.41	0		0	0	3.75		0.78	32.81	1		0.51	22.92	11.66		0.66	38.70
SD	14.57	0		0	0	4.04		0.93	30.53	1.27		0.81	29.81	14.44		0.74	40.42

Appendix IV D : Population density of nilgai (expressed in terms of %)in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	84	21	1.2002	17.49	41.66	37	3.237	11.49	27.37	8	0.7354	11.11	26.46	18	9.5	1.89	4.5
AUG	46	3	1.2002	2.49	29.32	1	3.237	0.31	3.65	1	0.7354	1.38	16.25	41	9.5	4.31	50.76
SEP	16	3	1.2002	2.49	42.2	10	3.237	3.10	52.54	0	0.7354	0	0	3	9.5	0.31	5.9
OCT	45	8	1.2002	6.66	24.14	8	3.237	2.48	8.99	12	0.7354	16.66	60.4	17	9.5	1.78	6.45
NOV	78	9	1.2002	7.49	22.1	28	3.237	8.69	25.64	25	1.578	16.02	47.28	16	9.5	1.68	4.95
DEC	166	27	2.4004	11.24	34.33	30	6.474	4.65	14.2	25	3.156	8.01	24.46	84	19	8.84	27.0
JAN	276	83	2.4004	34.57	45.24	69	6.474	10.71	14.01	84	3.156	26.92	35.23	40	19	4.21	5.5
FEB	358	80	2.4004	33.32	36.22	50	6.474	7.76	8.43	125	3.156	40.06	43.55	103	19	10.84	11.78
MAR	241	31	2.4004	12.91	20.14	18	6.474	2.79	4.35	131	3.156	41.98	65.49	61	19	6.42	10.01
APR	205	49	2.4004	20.41	36.47	17	6.474	2.63	4.69	85	3.156	27.24	48.67	54	19	5.68	10.15
MAY	259	49	2.4004	20.41	32.37	39	6.474	6.05	9.59	103	3.156	33.01	52.36	68	19	3.57	5.66
JUNE	205	50	2.4004	20.82	41.6	38	6.474	5.9	11.79	65	3.156	20.59	41.14	52	19	2.73	5.45
TOTAL	1979	413		190.3	405.79	345		66.56	185.25	664		242.98	461.29	557		52.26	147.46
$\bar{X}$	164.91	34.41		15.85	33.81	28.75		5.54	15.43	55.33		20.24	38.44	46.41		4.35	12.28
SD	109.65	28.07		10.72	8.40	19.39		3.52	13.95	49.19		13.98	18.93	30.05		3.12	13.62

Appendix IV E : Population density of wildboar(expressed in terms of %) in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	40	26	1.2002	21.66	91.23	3	3.237	0.93	8.91	0	0.7354	0	0	11	9.5	1.15	4.84
AUG	68	34	1.2002	28.32	73.63	32	3.237	9.93	25.81	0	0 7354	0	0	2	9.5	0.21	0.54
SEP	9	9	1.2002	7.49	100	0	3.237	0	0	0	0.7354	0	0	0	9.5	0	0
OCT	4	4	1.2002	3.33	100	0	3.237	0	0	0	0.7354	0	0	0	9.5	0	0
NOV	19	19	1.2002	15.83	100	0	3.237	0	0	0	1.578	0	0	0	9.5	0	0
DEC	34	26	2.4004	10.83	80.88	0	6.474	0	0	8	3.156	2.56	19.11	0	19	0	0
JAN	32	25	2.4004	10.4	82.47	0	6.474	0	0	7	3.156	2.21	17.52	0	19	0	0
FEB	37	31	2.4004	12.21	86.41	0	6.474	0	0	6	3.156	1.92	13.53	0	19	0	0
MAR	25	19	2.4004	7.91	80.46	0	6.474	0	0	6	3.156	1.92	19.53	0	19	0	0
APR	21	19	2.4004	7.91	96.22	2	6.474	0.31	3.77	0	3.156	0	0	0	19	0	0
MAY	25	10	2.4004	4.16	64.79	15	6.474	2.32	36.13	0	3.156	0	0	0	19	0	0
JUNE	13	13	2.4004	5.14	100	0	6.474	0	0	0	3.156	0	0	0	19	0	0
TOTAL	327	235		135.19	1056.69	52		14.57	69.62	27		8.61	74.74	13		1.36	5.38
$\bar{X}$	27.25	19.58		11.26	88.00	4.33		1.21	5.8	2.25		0.71	6.22	1.08		0.11	0.44
SD	17.00	9.24		7.44	11.71	9.63		2.83	11.94	3.05		0.97	7.99	3.17		0.33	1.39

Appendix IV F : Population density of feral cattle(expressed in terms of %)in different habitats

	Total Number of Animal	WOODLAND				GRASSLAND				SAVANNAH				AQUATIC			
		No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density	No. of Animal (N)	Area covered in sq km (A)	Density N/A	Percentage of density
JULY	705	8	1.2002	6.66	1.64	324	3.237	100.62	24.87	201	0.7354	279.16	69.0	172	9.5	18.10	4.47
AUG	370	0	1.2002	0	0	248	3.237	77.01	38.95	84	0.7354	116.66	59.01	38	9.5	4	2.02
SEP	521	9	1.2002	7.49	1.78	277	3.237	86.02	26.48	235	0.7354	326.38	77.72	0	9.5	0	0
OCT	177	30	1.2002	24.99	14.1	41	3.237	12.73	7.18	100	0.7354	138.88	78.36	6	9.5	0.63	0.35
NOV	291	0	1.2002	0	0	157	3.237	48.75	36.79	130	1.578	83.33	62.89	4	9.5	0.42	0.31
DEC	506	60	2.4004	49.99	42.77	368	6.474	57.14	48.89	21	3.156	6.73	5.75	57	19	3	2.56
JAN	610	77	2.4004	64.15	37.92	324	6.474	50.31	29.74	163	3.156	52.24	30.88	46	19	2.46	1.45
FEB	994	33	2.4004	13.74	6.53	652	6.474	101.24	48.15	299	3.156	94.04	45.06	10	19	0.52	0.24
MAR	900	32	2.4004	30.82	16.39	648	6.474	100.62	53.51	169	3.156	54.16	28.8	46	19	2.42	1.28
APR	1019	13	2.4004	10.83	6.74	602	6.474	93.47	58.18	131	3.156	41.98	26.13	273	19	14.36	8.93
MAY	736	37	2.4004	30.82	24.88	394	6.474	[illegible]	[illegible]	59	3.156	18.91	15.26	246	19	12.94	10.44
JUNE	673	8	2.4004	3.33	3.10	338	6.474	52.48	49.00	120	3.156	40.87	38.16	198	19	10.42	9.72
TOTAL	7502	312		242.82	155.85	4373		841.57	465.13	1721		1254.04	537.02	1095		69.27	41.77
$\bar{X}$	625.16	26		20.23	12.98	364.41		70.13	38.76	143.41		104.50	44.75	91.33		5.77	3.48
SD	268.07	24.34		20.54	14.87	189.07		27.59	15.41	76.80		100.77	24.42	101.26		6.37	3.95

Appendix VA - CHITAL: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND	++++	++++	+	+	++++	+	+	+
GRASSLAND	++++	++++	++	++++	+++	+	+	++
SAVANNAH	++++	++++	+++	++++	++++	+	+	+
AQUATIC	+++	+++	+	+	+++	+	+	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

\+ = Not Significant

Appendix VB - SAMBAR: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND	++++	++++	+	++++	+	+	+	+
GRASSLAND								
SAVANNAH								
AQUATIC	++++	++++	++	++++	+	+	+	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

\+ = Not Significant

Appendix VC - BLACKBUCK: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND								
GRASSLAND	++++	++++	++++	++++	++++	+	+	+
SAVANNAH	++++	++++	++++	++++	++++	+	+	+
AQUATIC	++++	++++	++++	++	++++	+	++	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

\+ = Not Significant

Appendix VD - NILGAI: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND	++	+	++	++	+	+	+	+
GRASSLAND	++++	++++	++	+	++++	+	+	+
SAVANNAH	++++	++++	++	+	++++	+	+	+
AQUATIC	++++	+++	++++	++++	++++	+	+	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

+ = Not Significant

Appendix VE - WILD BOAR: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND	+	+	+	++	+	+	+	+
GRASSLAND	++++	++++	+	+	++++	+	+	+
SAVANNAH	++++	++++	++++	++++	+	++	++	+
AQUATIC	++++	+++	+	+	+++	+	+	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

+ = Not Significant

Appendix VF - FERAL CATTLE: Levels of significance in the seasonal variation of different habitat.

HABITAT	Annual variation	Variation among season	Monthly Variation within the season			Variation between two season		
			Winter	Summer	Monsoon	Winter and Monsoon	Winter and Summer	Summer and Monsoon
WOODLAND	++++	++++	++++	++++	++++	+	+	+
GRASSLAND	++++	++++	+	+	++++	+	++	++
SAVANNAH	++++	++++	++++	++	+	+	+	++
AQUATIC	++++	++++	+	+++	++	+	+	+

++++ = Significant at Level P=0.001

+++ = Significant at Level P=0.01

++ = Significant at Level P=0.05

\+ = Not Significant